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Natural Resource Dependence, Volatility and Economic Performance in Venezuela: the Role of a Stabilization Fund

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INTRODUCTION

Latin America has been hurt by a series of economic shocks instigated by such events as the precipitous changes in oil prices of the past three decades, the periodic contraction in international credit and the currency crises of the past few years. Venezuela is particularly susceptible to volatility with severe implications on its economic performance. The IDB (1995) estimates that annual growth in Venezuela has been more than 3% lower than it would have been otherwise had there been no volatility.

When an economy undergoes a shock, the impacts can permeate every corner of the economy. The level of economic activity (GDP) can change, and with it the level of employment. The real exchange rate, one of the key determinants of a country's international competitiveness, can go through large movements, as can the relative performance of different domestic sectors, both tradeable and non-tradeable. Government budgets can be hit hard. Interest rates can undergo rapid fluctuations, affecting the financial health of corporations and the banks that depend on them, creating tensions in the entire national financial system. Finally, changing expectations of international markets regarding the solvency of the country can lead to self-fulfilling crises, destabilizing the macroeconomic climate.

In an economy susceptible to unanticipated shocks, economic agents must confront not only those shocks that have occurred but also those that might occur. This mix of uncertainty and instability has been termed volatility. Volatility affects countries' real economic performance as well as their perceived level of risk. [1]

Some countries are more susceptible to shocks than others. As established by the IDB (1995), the Latin America/Caribbean region has experienced more volatility than any other in the world with the exception of Africa and the Middle East. In volatile regions (or countries), GDP, employment, consumption, inflation, and investment tend to vary more erratically than in more stable areas. There is also evidence that productivity, poverty, income distribution, educational progress and strength of the financial system are negatively affected by greater macroeconomic volatility. The economic cost of volatility reveals that reducing and/or managing volatility offers potential benefits.

[1] Volatility and uncertainty are, in principle, two distinct concepts. Volatility refers to the tendency for a variable to fluctuate, while uncertainty exists only when those fluctuations are unpredictable. Nevertheless, in practice those quantities which are volatile tend also to be unpredictable, diminshing the relevance of this formal distinction. The most common unit of measurement to determine the degree of instability present in a variable is standard deviation, which represents the typical deviation of a variable from its mean value. See IDB (1995).

External shocks that affect the terms of trade and capital flows are an important determinant of a region's macroeconomic volatility and economic policy volatility. Moreover, important interactions between those shocks and economic policy must be considered in the design of policies and institutions intended to deal with unexpected shocks.

The principal cause of terms of trade volatility in Latin America—particularly in Venezuela—is the concentration of its exports in primary products whose selling prices are highly volatile. This lends great importance to policies intended to diversify exports and develop other strategies for reducing the risks associated with primary product exports.

Venezuela is one of the most volatile countries in the world, due to its (albeit decreasing) dependence on petroleum products subject to international price and production volume fluctuations (IDB 1995). It was nevertheless not until November 5, 1998, in the middle of a negative petroleum shock, that a lame-duck administration was able to push through the Macroeconomic Stabilization Investment Fund (in Spanish, *Fondo de Inversión para la Estabilización Macroeconómica*, or FIEM). The law establishing the Fund states it purpose as "preventing fluctuations in petroleum-related income from affecting the country's necessary fiscal, exchange rate, and monetary balance."[2] Curiously, the rules governing the Fund have been changed twice since the original passage of the law, most recently on October 4, 2001 (see Vera and Zambrano 2001).

To date, research on stabilization funds in Venezuela has consisted of 1) studies preceding the Fund's creation and focusing on its feasibility and optimal rule structure (Hausmann 1990, Hausmann & Powell 1990, Hausmann, Powell and Rigobón 1992); 2) statistical analyses of oil price series and their implications for stabilization funds' operations (Rigobón 1999 and Grisanti 2000); 3) estimations of the contribution of a stabilization fund relative to existing laws and international comparisons of rule structures for stabilization funds (Fasano 2000); and 4) the implications of continuing reforms to the FIEM law (Vera & Zambrano 2001).

The goal of the present work is design a multisectoral dynamic computable general equilibrium (CGE) model based on a Social Accounting Matrix (SAM) in order to evaluate the impact of stabilization mechanisms on Venezuela's macroeconomic balance. The model will take into account the Fund's medium-term investment plans, a variety of global and sectoral variables such as the exchange rate and fiscal policy, and the Fund's effects on factor allocation and income distribution within the country. The analysis seeks to contribute to the volatility policy debate by evaluating institutional alternatives for the Fund's management as well as its macroeconomic, sectoral, and institutional effects.[3]

Recent complementary studies using a similar empirical framework include Sachs and Warner (1995) and, for the case of Venezuela, Rodríguez and Sachs (1999). These works, however, focus mainly on the implications of natural resource abundance for medium-term economic growth.

The present work is organized into five sections. The first section presents the relationship between risk, volatility, policies, transmission channels and shocks—focusing on the case of Venezuela. The second section addresses the importance of the petroleum sector in the national economy. The third section analyzes stabilization funds as a mechanism for attenuating the effects of oil price oscillations—again highlighting the Venezuelan experience. The fourth section presents the analytical framework and simulation results. The fifth section concludes and discusses possible extensions of the work.

[2] The text of the law reads: "…procurar que las fluctuaciones del ingreso petrolero no afecten el necesario equilibrio fiscal, cambiario y monetario del país".

[3] Clemente and Puente (2000) review existing studies carried out in Venezuela that employ general equilibrium models.

1. RISK, VOLATILITY, POLICIES, AND TRANSMISSION CHANNELS

The countries of Latin America have been characterized in recent years by significant volatility among a broad range of real and financial variables that are proxies for macroeconomic stability that is critical for economic development. This has placed them at a disadvantage relative to other regions of the world, where changes in the those variables are less abrupt and more predictable (IDB 1995, Caballero 2001). This remains true inspite of reform programs instituted during this period.

Risks confronting economic agents come from two sources. First, they can reflect aggregate volatility which, in turn, results from world goods and financial markets, volatile fiscal or monetary policies, or other exogenous factors. The speed and extent of these shocks' transmission to agents' incomes and internal economic policies depend on market structure as well as the policies and institutions that govern the country. Second, these risks can spring from microeconomic or sectoral volatility, which have no necessary relation to aggregate disturbances.

It must be kept in mind that external factors are not the only cause of volatility in developing countries, since macroeconomic policies must bear part of the responsibility. Policy volatility—though partly resulting from errors of the governments that design it—is largely the product of large external shocks to financial and insurance markets as well as weak domestic agencies whose hands are frequently tied by their limited mandates.

Recent experience suggests that monetary policy volatility has been consistently high in Latin American countries. Over the last two decades, the region has been noted for recurring episodes of hyperinflation produced by the monetization of unsustainable fiscal deficits. Fiscal volatility is closely related to monetary instability, as inflationary responses to fiscal disequilibria have been among the principal causes of volatility in monetary aggregates in the developing world—including Latin America prior to the 90s. The two variables show a clear, positive correlation (World Bank 2000).

The volatility of macroeconomic policy nevertheless reflects the effects of external shocks on the domestic economy. This is particularly true in those countries where the public sector depends on income generated by primary products, such as in Chile, Ecuador, and Venezuela. In these countries terms of trade shocks have an immediate impact on the external sector and government income, and are clearly reflected in fiscal aggregates. Fluctuations in the terms of trade are apparently an important cause of fiscal volatility, which represents a third source of variation among different countries.

The extent of large shocks' impact is determined by the market structure, institutions and policies that play a key role in either absorbing or amplifying those shocks. Among these mechanisms, domestic and global financial markets may be the most important—especially since the mid-90s. But in most Latin American countries, weak links between global and domestic financial markets, often shallow and poorly functioning, greatly amplify shocks rather than helping accommodate them. This double weakness in financial markets is at the heart of recent Latin American macroeconomic volatility (Caballero 2001). Financial market imperfections in Latin America and the Caribbean strictly limit fiscal smoothing and the diversification of risk (Hausmann 2001 and World Bank 2000).

This propagation effect is especially evident in the banking system. As adverse shocks cause difficulties for domestic firms, the banking system's credit portfolio can deteriorate, in turn reducing the ability and willingness of the system to take on new risks and allocate resources efficiently. Certain borrowers can become barred from the credit market, only exacerbating the situation. When the financial position of the banking system is compromised, this sequence of events can bring banks to the brink of financial collapse, dragging even financially healthy borrowers down with them.

Weak capital markets also amplify the effects of shocks. Just as weak banking systems can lead to credit rationing, capital market failures can result in what might be termed "equity rationing"—the inability of firms to raise equity capital without incurring prohibitive costs.

The connection between underdeveloped financial markets and economic instability can be clearly seen on the international stage. In cross-country data, a larger domestic financial sector is correlated with lower levels of economic volatility—although this relationship weakens when financial sectors become extremely large. A rapid expansion of financial systems, particularly when poorly regulated and inadequately supervised, can also contribute to economic volatility (World Bank, 2000).

In addition to the financial system, there are other institutional and political factors that play a key role in either magnifying or containing the economic impact of shocks to the domestic economy. They include:

- Fiscal policy—frequently in the form of "automatic stabilizers"—consists of compensating for negative shocks with a corresponding expansion of aggregate demand, or reduction in the case of positive shocks. In Latin America and most of the developing world, however, fiscal policy is markedly pro-cyclical. This serves to accentuate expansion in booms as well as aggravate the contraction of recessions. Instead of compensating for shocks, then, fiscal policy can add to their attendant economic risk. To a certain degree this reflects the influence of financing constraints, as in recessions governments face drastic reductions in their access to foreign finance or large increases in its cost (Talvi and Végh 2000).

- Exchange rate and monetary policy can enable the domestic economy to weather the effects of external shocks. In this case, the objective must be to achieve a balance between credibility and flexibility over time. There are no easy recipes for successful monetary and exchange rate policy. Key elements of a policy that is viable on the medium term include simple and transparent rules and standards that are well adapted to the country's economic, political and institutional reality.

As in the case of other aggregate shocks, risk diversification is the best response to terms of trade volatility. This diversification can be achieved by selling, on international markets, the rights to a portion of future commodity revenues. In this way, domestic agents need not suffer the full impact of their volatility and can instead hold other assets instead (Engel & Meller 1992). The use of international futures markets—through the sale of future copper or oil production at prices fixed in advance, for example—is another way to diversify terms of trade risk. But in spite of their growth in recent years, futures markets remain limited. Futures prices often undergo great fluctuations, and the markets' operations remain focused on short-term instruments.

In view of insurance market limitations, various Latin American and Caribbean countries have resorted to self-insurance, in the form of commodity stabilization funds in order to manage terms of trade risk. These funds are designed to accumulate funds in periods of high commodity prices, to be drawn down when prices fall below a predetermined "reference" level. In contrast to true insurance, stabilization funds do not involve any true diversification of risk; rather, they merely transfer funds from good states of the world to bad. They also involve significant opportunity costs, as accumulated funds must be held in short term instruments and thereby forego the more attractive returns of less liquid investments. Engel and Meller (1992) review the experience of Latin American stabilization funds while Hausmann, Powell and Rigobón (1992) conduct a preliminary evaluation of Venezuela's FIEM.

Directly reducing the economy's exposure to terms of trade changes is another way to limit their potential damage. One way to do this is through export diversification, which reduces the impact of commodity price fluctuations by reducing the concentration of imports in a limited number of primary products.

In order to reduce the impact of external volatility on the domestic economy and encourage sustainable development strategies, an essential first step is to identify the channels through which shocks are transmitted. Recent studies suggest that fiscal expenditures can be the most important transmission channel, highlighting the importance of fiscal institutions and the application of fiscal rules (see Alesina, Hausmann, Hommes and Stein 1999 for a review of this issue focusing on Latin America and the Caribbean).

It is crucial that fiscal policy maintain its dual objectives of solvency and liquidity over time. Stabilization funds can help achieve this through numerical and procedural rules to guarantee their transparency and long-term viability. Other factors critical to success are effective management of international reserves, international debt policy, and political will (Engel & Valdes 2001 and Hausmann 2001).

In Venezuela, oil shocks are transmitted to the domestic economy via two principal paths—through fiscal expenditures, and through the terms of trade. Both impacts eventually affect expectations of the country's solvency and, without doubt, the medium-term performance of the real economy. If the shock is positive—that is, related to a rise in oil prices—there can be a sudden increase in the budget surplus and current account, followed a few months later by a rise in domestic public spending, especially when the next budget is negotiated. The result is pro-cyclical fiscal behavior. The new expenditures put upward pressure on aggregate demand, stimulating an increase in imports as well as an increase in the prices of non-tradeables due to short-term supply rigidities. This increase in non-tradeables prices can generate inflationary pressure, producing an appreciation of the real exchange rate, since during an oil boom the nominal exchange rate tends to remain stable.

This real appreciation in turn produces a twofold effect. First, it further stimulates imports, which have become cheaper relative to their domestic counterparts. Second, the fiscal balance can deteriorate.[4] Both effects combined can generate, over time, a deterioration of the current account as oil prices begin to fall below the local maximum achieved during the shock. Oil prices, public

[4] The favorable fiscal effect of a devaluation depends on how long inflation takes to match the pace of depreciation or devaluation that has occurred. The greater the degree to which the depreciation or devaluation of the currency is maintained in real terms, the more lasting will be the positive fiscal effect. On the other hand, the more rapidly domestic inflation adjusts to the rate of devaluation or depreciation, the more fleeting will be the fiscal effect (Clemente & Puente 2001).

spending, and the real exchange rate are clearly the variables revealing the effects of adjustment in both macroeconomic aggregates.

When the shock is negative—resulting from a fall in oil prices—ordinary fiscal revenues are significantly affected and measures to reduce public spending become necessary. Nevertheless, there are restrictions that ensure a temporal disconnect between the moment the shock occurs and the opportunity for budget institutions to react by raising income and/or lowering expenditures, thereby adapting internal absorption to the new equilibrium. This lack of policy coordination and/or institutional adaptation shows up in a greater fiscal deficit or lower surplus in the current account. Adjustment measures necessary to correct the disequilibrium can bring the economy into recession.

The other mechanism through which oil shocks are transmitted to the domestic economy is the terms of trade. Their effect can be seen not only in the exchange rate, where it can induce the expectation of depreciation, but also in slippage in the country's indicators of solvency and the performance of tradeable goods sectors.

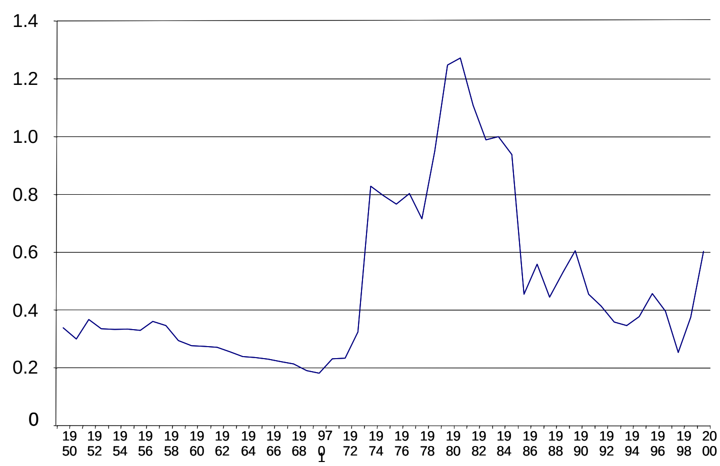
The volatility of oil income together with a lack of adequate institutional arrangements have resulted in pro-cyclical public expenditures. These have also subjected the economy to relatively short cycles, in which boom periods give way rapidly to crisis and recession, to be replaced shortly thereafter by recovery and a repetition of the cycle. This pattern obviously reflects not only the difficulties faced by monetary policy as well as the inability of fiscal policy alone to play a stabilizing role.[5]

[5] Blejer and Cheasty (1990) and Morgan (1979) show that in the case of publicly-owned primary product exporting countries, if the monetary impact of this income is not sterilized, its use to finance public spending will inevitably lead to expansionary effects on the money supply. This is particularly true in times of high prices for those products. In this way, the authors show that the domestic public deficit direclty impacts the creation of the monetary base. Various studies have corroborated this deficit concept in the Venezuelan case (Diz 1988 and Vaez-Zadeh 1989).

Figure 1.1.

Terms of Trade

(Export Price Index / Import Price Index)



Source: BCV, MEM, and authors' calculations.

The interaction between fiscal policy, exchange rates, and inflation has contributed to the instability of economic growth in Venezuela, since exchange rate adjustment to correct fiscal disequilibria and the associated contractionary effect of devaluation has had negative repercussions on growth.[6]

[6] See Edwards (1989), Krugman and Taylor (1978), and for the Venezuelan case, Hausmann (1990 and 1995).

2. VENEZUELA: AN OIL ECONOMY

Until the 1920s Venezuela was a rural, agricultural country whose primary exports were coffee and cocoa. Since that time, the discovery of large domestic oil deposits as well as high demand from the United States and Europe have contributed to extensive development of the petroleum industry. In Venezuela, oil was seen as a fiscal resource for the modernization of an agricultural, rural country when the Great Depression of the 1930s provoked a collapse of coffee and cocoa prices. Subsequent development of global oil markets allowed petroleum products to become and remain Venezuela's primary export. A national discussion on the role of the oil industry in Venezuela's destiny began in 1936 and intense debate continues to the present day (Clemente and Puente 2001). The relative importance of the petroleum industry in real economic activity (GDP) began in the 1920s and came to represent 31% of the economy by the 1960s. Its importance fell to just 20% by the 1980s, but by the 1990s recovered to 25% of GDP.

The high volatility of oil income is principally reflected in the balance of payments and the fiscal balance, due respectively to the relative importance of oil in exports and in fiscal revenue. This importance has, however, diminished since the 1970s. This can be seen in the fact that the positive oil shock of 2000 affected these variables to less than 40% of the degree to which they were affected by the 1974 shock.

Table 2.1.

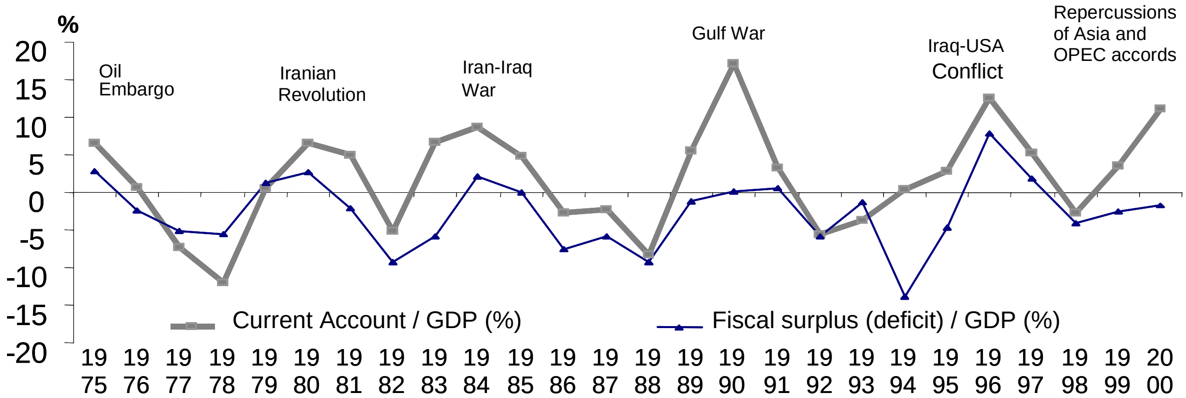
Importance of the Oil Sector in Venezuela

Indicators (%)	*1970-79*	*1980-89*	*1990-99*
Oil revenues/GDP	15.1	13.2	11.4
Oil revenues/Total government revenue	70.1	60.7	59.0
Oil exports/Total exports	87.4	82.2	71.1
Oil exports/GDP	23.0	21.2	20.5
Real oil GDP/Real total GDP	31.3	20.0	24.5

Source: Clemente and Puente (2001)

Figure 2.1.

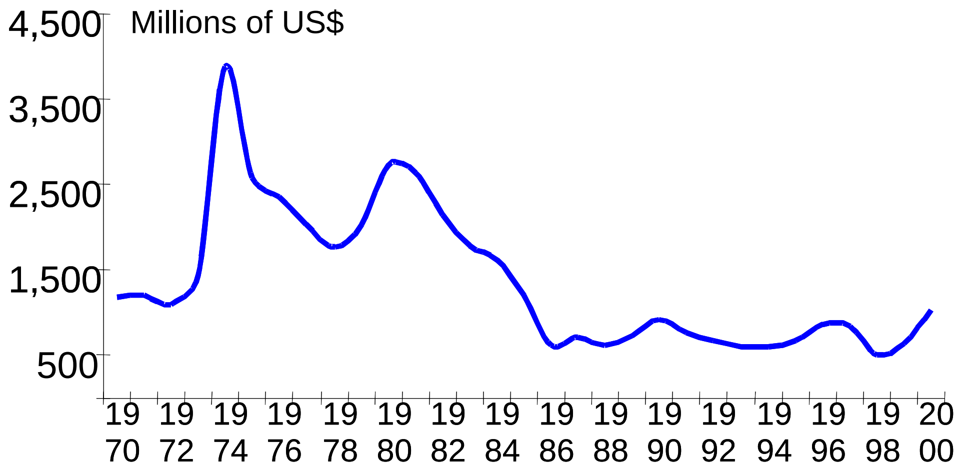
Current Account and Fiscal Balance (as % of GDP)



The non-oil sector in Venezuela is highly dependent on oil income and, consequently, on fiscal policy. This dependency severely restricts the freedom of monetary policy by making it essentially endogenous in respect to public spending.

Figure 2.2

Venezuelan oil exports per capita



This means that, in general, monetary policy must be counter-cyclical to public expenditure, complicating regulation of the money supply during fiscal expansions. At these times, the Central Bank must compensate for the expansion by absorbing excess resources from the economy.

In an economy like Venezuela's, with a high degree of dependence on oil income[7] and a tight link between oil income and fiscal expenditures, oil income volatility will be reflected in monetary aggregates unless the Central Bank or a stabilization fund adequately sterilizes income that is incompatible with inflationary or long-term debt objectives.[8]

[7] Appendix 1 discusses Venezuela's oil-related fiscal structure.

[8] The law establishing the Macroeconomic Stabilization Investment Fund (FIEM) was passed on November 5, 1998.

3. NONRENEWABLE RESOURCE FUNDS AND THE MACROECONOMIC STABILIZATION INVESTMENT FUND (FIEM) IN VENEZUELA

Stabilization funds are designed to reduce volatility by transferring resources from good years to bad. This is generally accomplished by accumulating money in a fund when economic circumstances are favorable, such that these funds can be draw upon in bad times. The economic and practical logic of smoothing out fluctuations caused by unexpected events is both compelling and fairly obvious.

The advantages on the real economy are several. Reducing fluctuations in the government budget will improve the continuity of critical public programs and increase the scope for carefully planning and implementing public projects. For the poorest segments of society, smoothing aggregate consumption will reduce temporary but potentially catastrophic declines in income. Reducing volatility in consumption will also reduce risk and costly risk aversion strategies, opening the way for potentially more profitable production possibilities. A steady course of aggregate investment will facilitate project selection and implementation and enhance maintenance of capital stocks, increasing the return on current and prior investments.

In addition to reducing the debilitating effects of frequent economic expansions and contractions, reducing changes in relative prices such as those mediated through the real exchange rate will provide solid benefits for producers. Finally, reducing volatility will reduce the problems associated with financial and monetary swings. The government will have an easier time maintaining macroeconomic balances, keeping inflation in check while promoting growth. Alleviating financial fluctuations will improve the depth of the financial system, providing benefits for the productive and financial sectors.

There are a variety of mechanisms and objectives for commodity and natural resource funds. Heritage funds are designed to increase overall national saving, aiming to smooth consumption over time by transferring wealth to future generations. The objective of heritage funds centers on the question of optimal savings. This is an economic issue that differs from the question of allocating financial assets, deciding whether to assign a fiscal surplus to financial assets or to invest these funds into public works or other capital creation efforts (Davis et al 2001).

Venezuela displays the key characteristics that would make it an obvious place to consider a heritage fund – a high portion of national income coming from a non-renewable resource – except that the high incidence of poverty makes such a strategy economically questionable and politically difficult. In this paper, we consider only the implementation of a stabilization fund that targets financial objectives rather than the question of optimal savings (see Grisanti 2000). In considering the financial issues, we attempt to smooth the inter-temporal allocation of national savings to reduce volatility. This strategy has the additional benefit of helping to ward off short-term financial crises, which are seen by some to be the most serious cost of volatility (Caballero 2000).

In theory, the stabilization fund could be operated by borrowing when prices are low and paying back the loan when prices are high. However, this is unrealistic in practical terms for two reasons. First, international financing is generally not available in adequate amounts in bad times. International financial markets will usually allow the country to borrow in good times (as they did in the 1960s in Bolivia), but when the country is hit by an adverse shock it may well lose its creditworthiness and face a decline in its borrowing capacity just when it needs it most. Second, the temptation of high revenues often leads to increased borrowing during good times rather than the opposite as suggested above. Because of these factors, stabilization funds must generally start by accumulating funds in order to be brought into operation. This reduction in current expenditures entails a cost of instituting the stabilization fund in the form of reduced consumption and lost investment and thus lower capital stocks and decreased production. The benefit of a stabilization fund thus has to be judged against this cost.

The accumulation of funds is one of the primary objectives of heritage funds. For a stabilization fund under consideration in here, we should prefer to minimize the amount of resources in the fund for a given level of volatility reduction. This is one the fundamental tradeoffs in designing a stabilization fund, limiting the amount of resources tied up in the fund while ensuring that adequate funds are available to achieve the desired stabilization objectives.

This of course assumes that returns to capital will be higher on equity participation in domestic investment projects than in holding foreign assets. Furthermore, we generally assume that returns to investment, or the fraction of the resources channeled into investment, are the same over different time periods. If for some reason waiting to carry out investments will increase the return on investment, then holding the resources in the fund abroad will provide benefits above those that stem from volatility reduction. These questions, though important, are beyond the scope of this paper.

Venezuela created the Macroeconomic Stabilization Investment Fund (FIEM) in 1998 to address the problem of volatility as the result of fluctuations in the price of oil. As we detail in Appendix 2, FIEM has undergone a number of changes since its inception. Based on the last revisions, the government will make contributions as a fixed proportion of fiscal revenues from petroleum into FIEM from the years 2003 through 2007. These contributions will start at 6% and increase by one percentage point each year until 2007. Starting in 2008, the fund will operate according to its originally developed rules. Revenue benchmarks will be calculated for government fiscal revenues and PDVSA export earnings based upon five year moving averages. Deposits and withdrawals into the fund will subsequently be made by comparing current revenues to these benchmark figures.

The FIEM deals with the issue of accumulating excessive resources in the fund by creating an upper limit on contributions into the fund. If fund resources are greater than 80% of a 5-year average of petroleum export revenues, then the surplus is funneled back into PDVSA accounts, national investment funds and paying down the debt. Further details about the FIEM can be found in Appendix 2. In a later section, we will assess the performance of the FIEM as it is currently planned in reducing macroeconomic volatility, versus two alternative designs.

The formulation of a stabilization fund does not by itself ensure that these macroeconomic objectives will be reached. Government funds are fungible, and it is well recognized that such a stabilization fund can be easily rendered ineffective if the government carries out an otherwise pro-cyclical fiscal policy, borrowing to increase expenditures during good years. This is in fact what appears to happened in Venezuela for the initial years of the stabilization fund. Public debt increased during this period, resulting in greater indebtedness rather than accumulated wealth. A stabilization fund will only be effective if it is accompanied by either borrowing constraints or by a program of fiscal discipline that eschews the temptation of pro-cyclical spending.

In fact, conservative fiscal policy by itself has the potential to achieve the same stabilization objectives. Much of the success and attractiveness of a stabilization fund is in its ability to foster fiscal discipline that would not otherwise occur. The political economy arguments for stabilization funds are as follows: 1) The existence of the Fund could reduce pressure on the government to raise expenditures in the event of rising revenues; 2) the implementation of the Stabilization Fund could be an opportunity to enact complementary fiscal rules that reduces the scope for borrowing and spending by the government; 3) it might be politically difficult to issue public debt in order to make planned payments to the Stabilization Fund. Normally the government would borrow when oil prices are high and in that way cause pro-cyclical spending. The very existence of a stabilization fund may make it more difficult for governments to issue new debt (Davis et al 2001).

3.1 The future of oil prices: Considerations for designing a stabilization fund

The stochastic behavior of petroleum prices and income is a critical element to consider in designing a stabilization fund for Venezuela. Knowledge of this underlying process is important not only to establishing the rules under which the fund operates but also the metrics by which its performance is to be measured. A principle question regarding the behavior of oil prices is whether they are stationary. If the price of oil is stationary, then following a shock the price will revert to the mean value, or trend: fluctuations in the price of oil in this context would be temporary. Within fiscal constraints, stabilization policy could then attempt to correct for all of the stochastic volatility. If oil prices are nonstationary, then oil shocks have a permanent effect on oil prices, and the question becomes how to adjust to the new level. In this case, however, Hausmann, Powell and Rigobón (1992) posit that a stabilization fund might still minimize the necessary adjustment costs.

As is extensively discussed in the related literature, a series of theoretical and practical difficulties complicate the exact characterization of the stochastic process. One interesting study is that of Eduardo Engel and Rodrigo Valdés, who evaluate 12 different models or variants of predictive models (out of sample) of oil prices.[9] The authors reach the conclusion that the best predictors are a simple random walk and an ARIMA model. They nevertheless point out that despite the difficult in rejecting the null hypothesis of nonstationarity of the series, theory suggests that this result may arise from sampling problems. Intuitively, this is because oil prices cannot long remain below the marginal cost of production, and conversely, high oil prices will stimulate production of oil as well as its substitutes—driving down the price. Another explanation suggested by Engel and Valdés relies on possible nonlinearities in the adjustment process. That is, the price may behave as a random walk only within a certain range, outside of which stabilization forces dominate. Another point raised by Engel and Valdés is the possibility of structural changes in the economy, since their conclusions vary depending on the number of years included in the analysis.

Pindyck (1999) proposes that such stationarity tests, when applied to small samples, may have very low power. Rigobón (1999) applies the methodology proposed by Pindyck, reaching similar conclusions. Table 3.1, below, reproduces some related work by Grisanti (2000) regarding the following oil prices, production volume, real exports, and per-capita real exports. The variables shown are in logarithms and the first differences of their values, maxima, minima, and standard deviations may therefore be interpreted as percent changes.

Although precise conclusions to be drawn from these data depend on the time period considered, general results include: a large year-to-year variation in the series, non-normality of distribution (shown in the positive skewness of prices, negative skewness of volumes, and high kurtosis), and significant first- and second-order autocorrelation of the variables.

Table 3.1.
Analysis of relevant variables
(Logarithms and first differences)

	Real price of WTI (West Texas Intermediate) oil, 1879-1999		Real price of Venezuelan oil, 1820-1999		Export volume 1925-1999		Real oil exports 1925-1999		Real oil exports per capita 1925-1999	
	Level	1st Diff.	Level	1st Diff.	Level	1st Diff.	Level	1st Diff.	Level	1st Diff.
Sample size	130	129	80	79	75	75	75	75	75	75
Average	2.64	0.00	2.43	0.00	0.57	0.03	8.96	0.04	6.70	0.01
Minimum	1.93	-0.66	1.83	-0.67	-0.95	-1.46	6.94	-0.56	5.58	-0.59
Maximum	3.70	0.71	3.63	0.87	1.24	0.35	10.10	0.73	7.61	0.70
Std. deviation	0.33	0.21	0.48	0.19	0.59	0.13	0.82	0.22	0.44	0.22
Skewness	0.74	-0.10	0.95	0.54	-1.10	-0.60	-0.90	-0.20	-0.50	-0.20
Kurtosis	4.12	4.42	2.76	7.97	3.40	6.08	3.05	4.70	2.60	4.58
Jarque-Bera	18.60	11.10	12.20	85.10	13.00	29.40	9.30	7.90	2.60	6.85
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.27	0.04
□ 1	0.91	0.02	0.92	-0.10	0.93	0.00	0.92	-0.10	0.85	-0.10
□ 2	0.82	-0.20	0.86	0.02	0.86	0.21	0.86	-0.10	0.73	-0.10

Note: ρ1 and ρ2 indicate, respectively, first- and second-order autocorrelation coefficients.

Source: Grisanti (2000)

The high volatility of these variables can be seen in the figures for standard deviation and kurtosis. The skewness of the production volume distribution more than makes up for that seen in prices, producing a negative skewness in real export income and indicating a larger number of years with prices below the mean than above it. Finally, the high degree of first- and second-order

[9] "Optimal Fiscal Strategy for Oil Exporting Countries," IMF Working Paper, June 2000.

autocorrelation reflect the great inertia in oil price, volume, and income cycles as well as the slow rate of mean reversion.

The stationarity analysis carried out by Grisanti is reproduced in Table 3.2. In this analysis, the variables were equally defined in logarithms of price levels (for different periods in the case of WTI), volumes, real exports and real exports per capita.

Table 3.2.

Integration test for relevant variables

	DF		ADF (2)		ADF(4)		ADF(8)		Sample
	C	CT	C	CT	C	CT	C	CT	
Real crude price (WTI)									
Log level	1%	1%	1%	1%	NO	10%	5%	1%	1870/
Log difference	1%	1%	1%	1%	1%	1%	1%	1%	1999
Real crude price (WTI)									
Log level	10%	NO	NO	NO	NO	NO	NO	NO	1920/
Log difference	1%	1%	1%	1%	1%	1%	5%	10%	1999
Real crude price (VEN)									
Log level	NO	NO	NO	NO	NO	NO	NO	NO	1920/
Log difference	1%	1%	1%	1%	1%	5%	10%	NO	1999
Export Volume									
Log level	1%	1%	1%	1%	5%	5%	5%	NO	1920/
Log difference	1%	1%	1%	1%	1%	1%	5%	5%	1999
Real crude exports									
Log level	1%	1%	1%	1%	NO	NO	NO	NO	1920/
Log difference	1%	1%	1%	1%	1%	1%	1%	1%	1999
Per capita real crude exports									
Log level	1%	1%	1%	1%	5%	NO	NO	NO	1920/
Log difference	1%	1%	1%	1%	1%	1%	1%	1%	1999

Notes: Critical values of DF= Dickey-Fuller and ADF(r)= augmented Dickey-Fuller with r lags. 'NO' indicates that the test was rejected at the 10% significance level. 'C' indicates that only the constant is included in the test, whereas 'CT' indicates that both the constant and a trend term are included.

Source: Grisanti (2000).

In general, the results indicate that the variables are stationary in levels, though the behavior of prices show mixed results. It is interesting to note that studies of the Venezuelan price index fail to reject the hypothesis of a unit root in levels, as does the same test applied to WTI (West Texas Intermediate) for the same time period, but when this latter test is extended to a longer time series the result reverses. This suggests that the nonstationarity result for Venezuelan prices may be an artifact of small sample size.

Using this empirical basis, we calculate different international oil price scenarios used for the general equilibrium model. These price projections., which are presented in Appendix 3, feature a long-term price trend to which prices revert after negative and positive shocks are imposed. In considering the design and performance of a stabilization fund, the disparity between stationary and nonstationary price trends is not as pronounced when considering a slow reversion to the mean value. Moreover, the rationale for operating a stabilization fund applies in either case: there appears to be sufficient empirical evidence to recommend a stabilization mechanism for the Venezuelan economy.

4. THE MODEL: DESCRIPTION, SIMULATIONS, AND RESULTS

In this section we will first describe the Computable General Equilibrium (CGE) model that we use, and then we will use the model to analyze the performance of the stabilization fund.

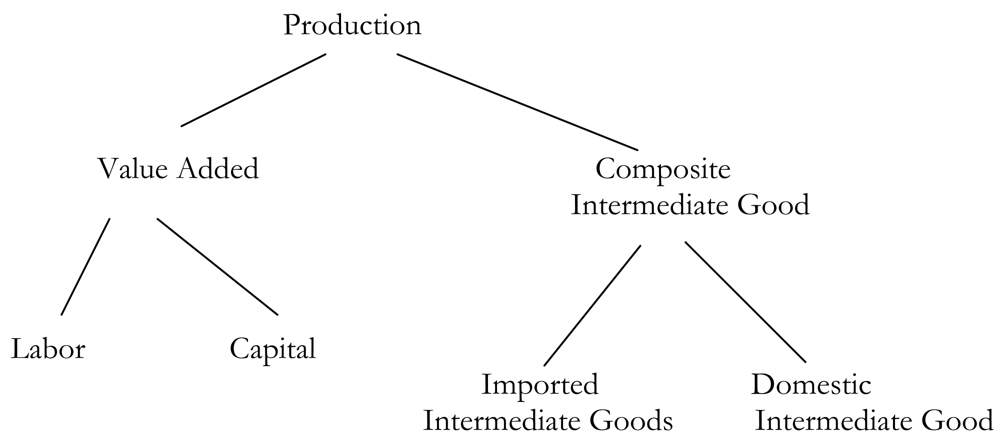
4.1. Specifying the key equations of the CGE model

The model developed for this study is a standard 3-sector recursively dynamic model. The three sectors described in the model are the petroleum sector, non-oil tradeables sector and the non-tradeables sector. This three sector approach is intended to capture the most important intersectoral impacts of changing oil prices and the volatility this brings in the simplest possible terms. The foundation of the model is a social accounting matrix constructed by the authors based on 1996 data. Capital is divided into two classes, that used by the petroleum industry and that used by the rest of the economy. In the model, investment in the petroleum is determined exogenously, and is based on PDVSA projections. Employment in the petroleum sector is treated in the same manner.

Labor is divided into three classes, urban skilled, urban unskilled and rural. To reflect the medium-to-long term time horizon, we allow labor to migrate between the rural sector and the urban unskilled sector. There are four household categories defined according to the source of income.

In the petroleum sector, production is fixed exogenously according to industry forecasts. For the tradeable and non-tradeable sectors, output, prices and factor demands are all determined endogenously within the model. Production is portrayed with a multiple-stage nested function. Labor and capital are combined in a Cobb-Douglas relationship to produce value added. Value added and composite intermediate goods are then pooled in a constant elasticity of substitution (CES) function. Domestic intermediate inputs are used in fixed proportions to form the aggregate domestic intermediate factor. Imported intermediate goods are combined with domestically produced intermediates using a CES function. This formulation is constructed to reflect the flexibility in production choices for medium to long-term processes.

Figure 4.1. Production Functions for the CGE Model



As one of the principal foci of this analysis is the study of the accumulation of capital in the face of price volatility, the treatment of capital is somewhat distinct from what is generally found in these models. Using a putty-clay depiction of capital, factors become more rigid in the production process once capital has been installed. Following Jacoby & Wing (1999), we assume that a given portion of capital is converted to a fixed coefficient production function after each investment period, in this case one year. This builds into this model a production context where managers cannot freely substitute intermediates, labor and capital in response to changes in wage rates and the cost of capital. This creates a context whereby prior investments made upon expected future relative prices can lock producers into sub-optimal production technologies.

The model is solved recursively over a thirty-year time horizon. The model is run for each time period, after which the stocks of accumulated factors are updated before the model is run again for the next period. The key aspect of defining the dynamic relationship in a macroeconomic model is the treatment of savings and investment behavior. In this model, aggregate investment is determined by national savings. First, savings is fixed as a fixed percentage of income for households and corporations according to their observed marginal propensity to save. Government savings is determined endogenously as the remainder after predetermined expenditures are subtracted from current revenues. In the absence of a solid empirical basis for estimating foreign savings levels, these are set exogenously as a percentage of GDP using historic levels. Once the level of aggregate savings is determined, the allocation of investment is determined by relative profitability based upon current prices. This is an alternative formulation to fully dynamic models where consumers and producers make savings and investment decisions based upon perfect price information for all future periods, recognizing that decision-makers are imperfect predictors of the future.

Factor demands are determined by profit maximizing behavior. Two types of rigidities are built into the model to better mirror reality. Firstly, investment decisions are made according to prices that prevail at the time of the decision. This acts as a proxy for expected prices. This investment is committed to the sector, even though prices will have changed when the investment is brought into production in the next time period. This means that investment decisions, and hence capital allocation decisions, are made with imperfect information regarding future prices, allowing for the sub-optimal allocation of capital. The second rigidity arises from the putty-clay formulation of capital mentioned earlier. The combination of capital, labor and intermediates is made at the time of the investment decision. In future periods, a portion of the production process takes place with this less-than-perfect mixture of factors and inputs. The magnitude of both of these impacts varies with the size of relative price changes across different time periods.

The relationship between imports and domestically produced commodities, as well as the relationship between exports and domestically consumed commodities, are treated in the standard way for CGE models, using an Armington function for imports and a constant elasticity of transformation (CET) function for exports. This formulation entails the imperfect substitution between these different commodities which allows for two-way trade as in observed trade relations.

This permits the elasticity of substitution between imports and domestically produced goods for these different sectors to vary, and hence for scenarios to look at different taxation schemes and world price trends by import type.

Labor markets operate in the manner used by De Santis (2000). Using the empirical observations of Blanchflower & Osward (1994) and others, a relationship between real wage rates and unemployment is specified, where higher wages coincide with lower unemployment. The empirical basis of the 'wage curve' mimics a labor supply curve when specified in a simulation model. Thus the labor markets operate on the principles of supply and demand in the model, rather than the usual choice between fixing wage rates or fixing labor supply curves. A full listing of the equations in the model are included in Appendix 5.

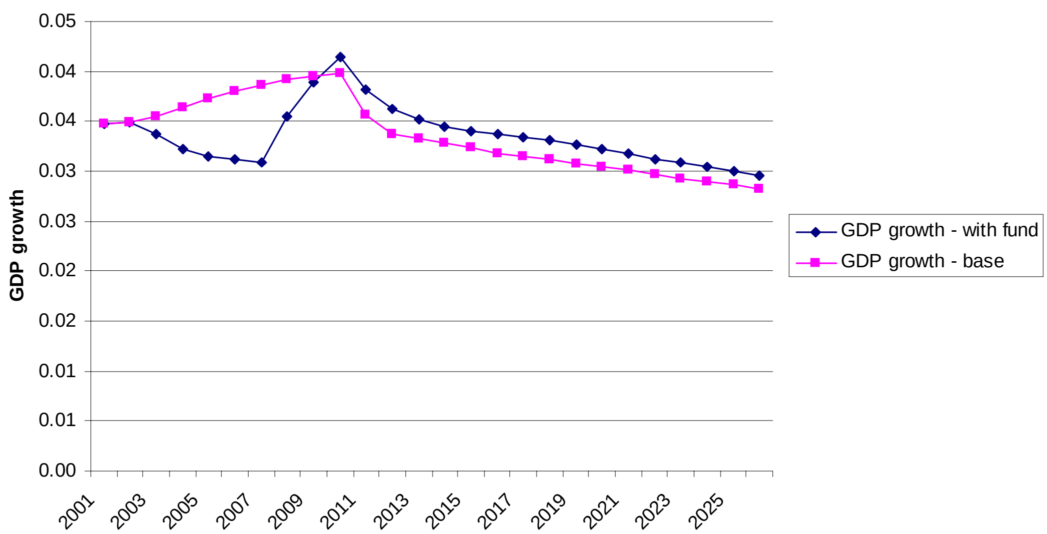
4.2 The costs of maintaining a stabilization fund

The economic cost of maintaining a stabilization fund is the result of setting aside a portion of petroleum revenues in a fund abroad rather than allowing these funds to be utilized within the economy. Reduced government expenditures and investments is the primary avenue, though PDVSA expenditures are expected to decline as well. We simulate these costs in the CGE model by comparing a scenario with the stabilization fund versus a scenario without the fund. Both of these initial scenarios are based upon baseline oil price projections.

The model predicts a growth rate for the Venezuelan economy of between 3 and 4 percent annually. Growth drops off after 2011 as we assume no further expansion of oil beyond that point. It is important to note that we do not suggest that this model will be a good predictor of future levels of economic growth. The model ignores the important influence of productivity gains on growth so that growth in production reflects factor accumulation only. While this is an important component of growth, it presents an incomplete picture. Secondly, this is a model of the real economy. Therefore, it does not incorporate the influence of financial and nominal factors on economic performance. Finally, we don't presume to know what international prices will do over the next 25 years. This model is most useful in observing the difference in performance of the economy between different scenarios, rather than predicting accurately future levels of economic output.

The first question we approach is the cost imposed on the Venezuelan economy by the stabilization fund under the assumptions of the base scenario. Figure 4.2 shows that the cost in terms of growth and output is quite small. The drop in growth is the result of the Stabilization Fund drawing savings and investments away from the economy. Under this scenario, deposits are made into the Stabilization Fund from 2003 until 2007. After 2008, although revenues continue to grow, resources are withdrawn from the fund each year in order to maintain the maximum size of the fund below the ceiling. In relative terms, the fund reaches its maximum size in year 2008 as it approaches 20% of GDP. Wages are somewhat suppressed by the operation of the fund.

It is important to note that this model is well suited for accounting for the costs of the stabilization fund, yet does not account for many of the benefits. The benefits of reduced volatility, as summarized earlier, might be manifest in the economy through greater efficiency in capital creation, improved efficiency in factor utilization – bringing on higher returns to labor and capital and perhaps higher productivity growth – and higher overall rates of investment in the economy, both in physical and human capital, leading to higher rates of factor accumulation and productivity growth. While the theoretical and empirical cases for these processes are strong, the empirical work in this area has only taken place at a fairly aggregate level, leaving us without an adequate basis for simulating these benefits.[10] Nonetheless, if the benefits of reducing volatility are even a fraction of the estimates presented earlier, it is easy to conclude that the benefits of reducing volatility will far exceed the costs.



We turn to the question of how well such a stabilization fund will perform in reducing volatility.

Figure 4.2. GDP growth with and without the Stabilization Fund

4.3 Performance of the stabilization fund in the presence of price shocks

We start by looking at the impact of positive price shock. Positive price shocks are generally considered a good phenomenon because of their expansionary tendencies. They do, however, bear potential complications. One of the ramifications of the relative price shifts is price volatility,

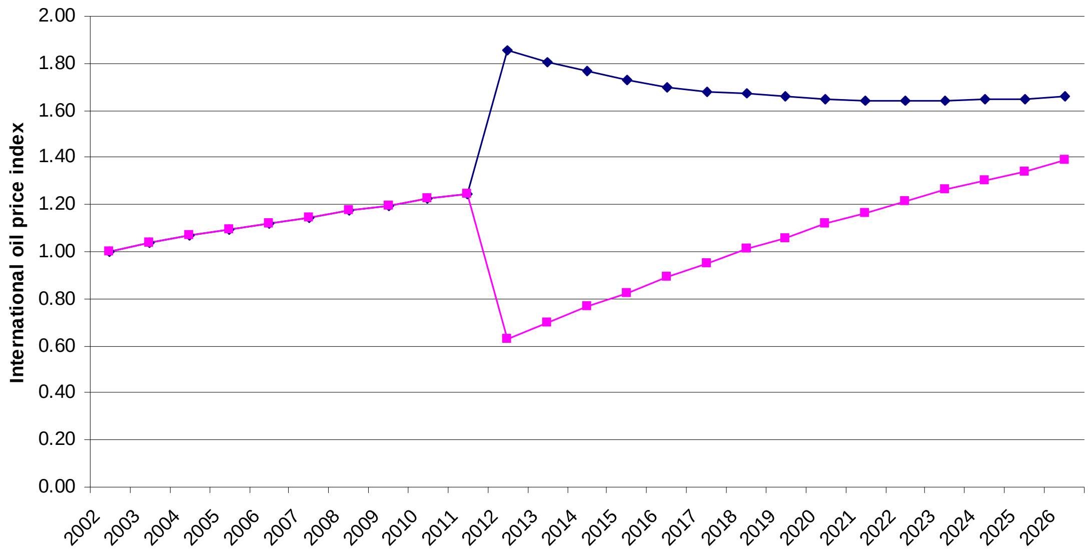
[10] One benefit of volatility reduction that the model picks up is the impact of capital misallocation as the result of fluctuating relative prices. We find this effect to be quite small, suggesting that this is not one of the primary channels whereby volatility reduces growth.

particularly for the non-petroleum tradeable sector which will suffer from the expected appreciation of the exchange rate. If the shock is permanent, then the economy will adjust to a new equilibrium, with a difference composition of the economy. This is in itself not a problem. Rather it is frequent changes in prices, i.e. temporary shocks, that will cause the expansions and contractions of different sectors of the economy, reducing the profitability of all sectors. In a sense, the country is unable to establish its comparative advantage, as this is constantly changing. A commonly cited manifestation of this is where the tradeable sector is largely dismantled during a resource boom, and is then ill-prepared to take advantage of more favorable conditions during the inevitable downturn in international oil prices. A related set of issues arises out of the expectations that are generated during boom periods. For example, expectations of revenue and expenditure patterns by the government may lead to unsustainable levels of investment and unfinished public works programs.

A stabilization fund is primarily thought of as an instrument to cushion an economy from downturns in international oil markets. However, if the objective of the fund is to decrease volatility, then it has a role to play on both upturns and downturns. Smoothing the transition of the economy to changes in international oil prices applies equally to resulting economic expansions and contractions.

The trajectory of the price path for oil with a positive price shock, as estimated in the analysis summarized in Appendix 3, is presented in Figure 4.3. Using this price path, we run the simulations using four possible scenarios: 1) no stabilization fund – NO FUND; 2) the Venezuelan stabilization fund in its current configuration - FIEM; 3) and two alternative configurations for the stabilization fund – ALT FUND 1 and ALT FUND 2. We have created the alternative fund rules to test for their performance in correcting what we see to be problems with the FIEM.

Figure 4.3. Projected International Oil Price Paths with Positive and Negative Shocks



One apparent flaw in the FIEM is that it requires deposits from the years 2003 until 2007 regardless of the context, whether prices are low or high, falling or rising. This could create the situation where the stabilization fund exacerbates an economic downturn stemming from a drop in oil prices. This feature of the FIEM should be corrected with a contingent rule that only mandates deposits in years where oil revenues are better than average.[11]

The second aspect of the FIEM that may be improved is that a rigid upper limit has been placed on the size of the fund, and this limit has been set in respect to an average of recent export revenues. A priori, this seems like a poor choice for two related reasons. First, selecting past oil revenues as the relevant benchmark for the size of the fund introduces the possibility that the fund will be prevented from taking on further deposits in the event of significant price rise. This will occur with a rise in oil prices following a period of low oil revenues, which will have created a low upper limit on the size of the fund. If using an upper limit for the size of the stabilization fund, it is better to choose a benchmark based only on current revenues or, perhaps more appropriately, a benchmark proportionate to the size of the economy, for example, GDP itself. Second, a rigid upper limit to the fund will mean

[11] Although we do not report the results of simulations run with a negative price shock during the accumulation stage from years 2003-2007, the results are as expected: a sharper drop in growth in the presence of the stabilization fund and larger swings in the real exchange rate, wages, and the real variables tracked by the model.

that deposits will be abruptly shut down and/or reversed to withdrawals without regard to the price path. This could, in fact, add volatility to the economy.

To correct for these aspects in the FIEM, we created ALT FUND 1, which has modified rules. First, it uses contingent rules in the initial 5 years of the fund identical to the long-term rules of the fund, comparing current revenues with an average of past revenues. Second, there is no ceiling on the size of the fund.

In place of a ceiling on the fund, the contingent rules of the fund are designed such that the size of deposits into the fund vary according to the size of the fund. For this feature, we use a simple formula to determine the percentage of the surplus in revenues above the benchmark that will be deposited (SFDPCT), where SFUND is the size of the fund in the domestic currency and GDP is real gross national product:

$$SFDPCT = 1 - \alpha \left(\frac{SFUND}{GDP} \right)^{\beta}$$

Both parameters, α and β, are set at 2 to create the following deposit schedule:

SFUND/ GDP	SFDPCT
0	100%
.1	98%
.2	92%
.3	82%
.4	68%
.5	50%
.6	28%
.7	2%

Compared to a ceiling on the size of the fund, this formulation creates a more gradual transition to reducing deposits into the fund. This aspect is only relevant in the presence of increasing oil revenues, either a positive oil price shock or expanding production. For negative price shocks, there is much less rationale for scaling the size of withdrawals to the size of the fund. We therefore have asymmetric rules for this version of the fund.

While the configuration of ALT FUND 1 provides an apparent improvement to the FIEM, there are still scenarios where the contingent rules will prevent the fund from providing the means to meet the objectives of the stabilization fund. Specifically, in the event of a significant positive price shock after the fund has already accumulated a lot of resources, deposits into the fund will be restricted. To address this issue, we design another alternative fund configuration, ALT FUND 2. This stabilization fund mechanism maintains all the features of ALT FUND 1, but adds another determinant to the size of deposits -- the size of the fluctuation in the international price of oil. In this case we use a logistic function to determine a second variable that influences the percentage of the surplus that is deposited in the fund (SFDPCT), where Δ is the percentage change in the international price of oil:

$$SFDPCT = 1/\left(1 + \phi \cdot e^{-\varphi \cdot \Delta}\right)$$

ϕ and φ are set to 100 to create the following deposit percentage schedule:

Δ	SFDPCT
0%	1%
1%	3%
2%	7%
3%	17%
4%	35%
5%	60%
6%	80%
7%	92%
8%	97%
9%	99%
10%	100%

Combining the two new elements, we now define SFDPCT to be the greater of the two. This formulation brings about the following regimen for the stabilization fund. There are two reasons that the deposit percentage could be high, either because the fund is small or there is a large change in international oil prices that warrants fund activity. There is only one context in which deposits are suppressed: the fund is large and the positive oil price shock is small.

As presented in Table 4.1, the FIEM does not perform well in reducing volatility in the face of a positive price shock. There is increased volatility in both government revenues and in the real exchange rate. Similarly, the growth trajectory in consumption and investment also displays more volatility compared to the base scenario with no stabilization fund. The two alternative funds perform better, although with some mixed results. ALT FUND 2 reduces real exchange rate and GDP growth volatility better than the other alternatives, but at the cost of increased volatility in government revenue growth and aggregate investment growth. ALT FUND 1 out-performs the FIEM in all aspects. Compared to ALT FUND 2, ALT FUND 1 does not reduce real exchange rate and consumption growth volatility as well, but performs better in smoothing government revenue growth and investment growth.

Table 4.1. Aggregate Volatility Indicators Results – Positive Price Shock

	High price path	
	Standard deviation	Mean value
GDP - ALT FUND 2		5299
GDP - ALT FUND 1		5308
GDP - FIEM		5385
GDP - BASE		5453
GDP growth - ALT FUND 2	0.0029	0.034
GDP growth - ALT FUND 1	0.0028	0.034
GDP growth - FIEM	0.0036	0.035
GDP growth - BASE	0.0036	0.035
Exchange rate - ALT FUND 2	0.0715	0.938
Exchange rate - ALT FUND 1	0.0721	0.938
Exchange rate - FIEM	0.0786	0.932
Exchange rate - BASE	0.0718	0.934
Exchange rate growth - ALT FUND 2	0.0346	0.000
Exchange rate growth - ALT FUND 1	0.0397	-0.001
Exchange rate growth - FIEM	0.0504	-0.001
Exchange rate growth - BASE	0.0448	-0.001
Government revenue - ALT FUND 2	533	1519
Government revenue - ALT FUND 1	532	1523
Government revenue - FIEM	583	1586
Government revenue - BASE	543	1597
Government revenue growth - ALT FUND 2	0.0528	0.045
Government revenue growth - ALT FUND 1	0.0443	0.045
Government revenue growth - FIEM	0.0538	0.047
Government revenue growth - BASE	0.0447	0.046
Consumption growth - ALT FUND 2	0.0137	0.036
Consumption growth - ALT FUND 1	0.0149	0.036
Consumption growth - FIEM	0.0244	0.038
Consumption growth - BASE	0.0203	0.037
Investment growth – ALT FUND 2	0.0341	0.039
Investment growth – ALT FUND 1	0.0287	0.039
Investment growth - FIEM	0.0429	0.041
Investment growth - BASE	0.0333	0.040

This analysis highlights the trade-offs in achieving the many possible objectives in reducing volatility. The enhanced performance of the two alternative funds in reducing most of the aggregate volatility indicators comes at the cost of increasing the size of the fund, keeping a larger portion of national savings away from production use. For example, the size of the fund in scenario ALT FUND 2 reaches a level equal to 66% of annual GDP compared to a level of 20% using the FIEM. The estimated reduction in growth for the ALT FUND 2 averages 0.7% per year. Again, it is not possible in this framework to explicitly quantify whether this is a good choice, but the weight of available evidence suggests that it is.

The last aspect associated with a positive price shock that we analyze is the impact on producer prices in domestic currency. Table 4.2 indicates that the reduction in most of the macroeconomic volatility indicators, including the real exchange rate, does not necessarily translate into a reduction in producer price volatility. For the petroleum sector, the movement in the real exchange acts to buffer much of the change in prices in the absence of the stabilization fund. By putting in place the stabilization fund, we are effectively reducing the price smoothing capacity of real exchange rate movements. For the non-tradeable sector, we are reducing the real exchange rate shock, but also reducing the impact of increased domestic spending. The net result is greater volatility in domestic prices for the non-tradeable sector. The tradeable sector is the only sector that enjoys mildly reduced domestic producer price volatility due to the activity of the stabilization fund.

Table 4.2. Impact of Positive Price Shock on Producer Prices in Domestic Currency

	Standard deviation	Mean value
Petroleum producer price - ALT FUND 1	0.162	1.141
Petroleum producer price - FIEM	0.161	1.134
Petroleum producer price - BASE	0.171	1.138
Non-tradeable producer price - ALT FUND 1	0.048	0.957
Non-tradeable producer price - FIEM	0.048	0.961
Non-tradeable producer price - BASE	0.048	0.962
Tradeable producer price - ALT FUND 1	0.056	0.944
Tradeable producer price - FIEM	0.056	0.944
Tradeable producer price - BASE	0.056	0.944
Petroleum producer price growth - ALT FUND 1	0.0305	0.0139
Petroleum producer price growth - FIEM	0.0287	0.0138
Petroleum producer price growth - BASE	0.0230	0.0140
Non-tradeable producer price growth - ALT FUND 1	0.0135	-0.0044
Non-tradeable producer price growth - FIEM	0.0205	-0.0041
Non-tradeable producer price growth - BASE	0.0109	-0.0044
Tradeable producer price growth - ALT FUND 1	0.0321	-0.0024
Tradeable producer price growth - FIEM	0.0387	-0.0022
Tradeable producer price growth - BASE	0.0337	-0.0024

We now turn to the impact of the fund in the presence of a negative price shock. This is the more obvious context for expecting the stabilization fund to reduce volatility, as it should not only address the price fluctuations but also reduce the contractionary impact of the price drop. For this section, we drop the second alternative fund configuration, ALT FUND 2, because in the context of a negative price shock, it performs identically to ALT FUND 1. As can be seen in Table 4.3, both funds perform quite well in reducing the aggregate volatility indicators when faced with a negative price shock. ALT FUND 1 again out-performs the FIEM on all of the measures except GDP growth volatility. This is largely the result of a smoother transition path between deposits to and withdrawals from the fund.

Table 4.3. Aggregate Volatility Indicator Results – Negative Price Shock

	High price path	
	Standard deviation	Mean value
GDP - ALT FUND 1		4969
GDP - FIEM		5035
GDP - BASE		5070
GDP growth - ALT FUND 1	0.0060	0.029
GDP growth - FIEM	0.0056	0.030
GDP growth - BASE	0.0072	0.030
Exchange rate - ALT FUND 1	0.0682	1.033
Exchange rate - FIEM	0.0760	1.028
Exchange rate - BASE	0.0883	1.029
Exchange rate growth - ALT FUND 1	0.0419	-0.001
Exchange rate growth - FIEM	0.0634	-0.002
Exchange rate growth - BASE	0.0795	-0.003
Government revenue - ALT FUND 1	330	1309
Government revenue - FIEM	374	1357
Government revenue - BASE	356	1362
Government revenue growth - ALT FUND 1	0.0492	0.039
Government revenue growth - FIEM	0.0570	0.041
Government revenue growth - BASE	0.0577	0.041
Consumption growth - ALT FUND 1	0.0077	0.030
Consumption growth - FIEM	0.0150	0.032
Consumption growth - BASE	0.0154	0.032
Investment growth – ALT FUND 1	0.0271	0.031
Investment growth - FIEM	0.0427	0.033
Investment growth - BASE	0.0485	0.033

The impact of the stabilization fund on producer prices for a negative price shock displays ambiguous results, similar to the results of the positive price shock. In the petroleum sector, a freely floating exchange rate more effectively buffers domestic price movements than the actions of the stabilization fund. The stabilization fund smoothes movements in the tradeables sector domestic prices as they are linked to the real exchange rate. The results for the non-tradeable sector is more complex with price movements that are linked more closely to the activity of the fund in addition to the real exchange rate and the activity of the fund. In this context, the withdrawals from the stabilization fund reduce expenditures on non-tradeables while the activity of the fund prevents a larger appreciation of the exchange rate. The net result is more volatility for producer prices in the non-tradeables sector.

Table 4.4. Impact of Negative Price Shock on Producer Prices in Domestic Currency

	Standard deviation	Mean value
Petroleum producer price - ALT FUND 1	0.105	1.006
Petroleum producer price – FIEM	0.102	1.001
Petroleum producer price - BASE	0.099	1.000
Non-tradeable producer price - ALT FUND 1	0.037	1.000
Non-tradeable producer price - FIEM	0.035	1.002
Non-tradeable producer price - BASE	0.035	1.003
Tradeable producer price - ALT FUND 1	0.043	0.995
Tradeable producer price - FIEM	0.048	0.996
Tradeable producer price - BASE	0.046	0.995
Petroleum producer price growth - ALT FUND 1	0.0632	0.0118
Petroleum producer price growth - FIEM	0.0563	0.0112
Petroleum producer price growth - BASE	0.0446	0.0106
Non-tradeable producer price growth - ALT FUND 1	0.0296	-0.0034
Non-tradeable producer price growth - FIEM	0.0265	-0.0033
Non-tradeable producer price growth - BASE	0.0157	-0.0035
Tradeable producer price growth - ALT FUND 1	0.0332	-0.0011
Tradeable producer price growth - FIEM	0.0448	-0.0007
Tradeable producer price growth - BASE	0.0509	-0.0005

Additional analyses were carried out to test the robustness of these results in different economic contexts. The oil price path used for the analyses above are constructed using historical data without considering explicit predictions about increases in future demand or technological advances, either in oil extraction or in alternative energy sources. To consider the performance of the stabilization fund in a less optimistic context, we also created a second price path in which prices revert to a lower long-term level. When evaluated using a lower price path for international oil markets, all three of the funds performed moderately better. These results are presented in Appendix 4. Altering the timing and magnitude of the price shocks did not substantially change the results.

The calculation of the benchmarks that drive the direction and quantity of stabilization activity are defined by past petroleum revenues. Selecting a longer time period for defining these benchmarks will create a longer, smoother transition to price shocks, reducing further volatility, but requiring more assets in the fund (Andersen and Faris, 2002). Defining benchmarks with a shorter historical time period will induce a more rapid adjustment to new prices, which implies more volatility than a longer transition.

4.4 Discussion and policy implications

The analysis carried out for this study provides evidence that supports the idea that a stabilization fund can reduce volatility in the Venezuelan economy. This volatility reduction and its associated benefits does come at the cost. Ignoring for a moment the political difficulty of accumulating national wealth in a stabilization fund, the most fundamental tradeoff to consider in designing the best fund is how to manage the size of the fund. In this analysis we describe and test two kinds of stabilization funds. One only effectively mitigates the impact of downturns but requires the accumulation of less resources. The other buffers the impact of both upturns and downturns, although this necessitates the accumulation of more resources. The arguments that Venezuela should engage in greater precautionary savings than other countries supports a strategy for erring on the side of accumulating more resources in the fund in the pursuit of greater volatility reduction.

It is also clear that volatility does not affect all facets of the economy in the same way, and attempts to reduce volatility may in fact increase volatility in some parts of the economy. This greatly complicates the design of a stabilization fund that is based on contingent rules that dictate the required activities of the fund, particularly where the objectives are defined in broad terms. One logical extension of this observation might be to retain a certain degree of discretionary control over the fund for policy makers. However, it has also been argued that the success of the fund hinges upon its ability to foster fiscal discipline. This is accomplished by effectively tying the hands of government leaders that might be tempted to forsake fiscal prudence in exchange for what is politically expedient. This is one of the key decisions in the design of the stabilization fund – how much discretionary control to put into the hands of policy makers in shaping the activity levels of the fund.

An additional complicating factor that colors this decision is the role of foreign capital flows. This is one important confounding factor that this modeling framework does not adequately address -- the interaction between volatility and foreign capital flows. Foreign capital flows is one of the mechanisms that might increase growth following a reduction in volatility. It is also one of the primary contributors to volatility and a factor that could reduce or reverse the expected volatility reductions resulting from the stabilization fund. For example, if foreign capital inflows are negatively correlated with volatility, then capital inflows could offset deposits made into the stabilization fund, bringing back the volatility the fund sought to eliminate. This supports the notion of either instituting complementary mechanisms to the operation of the stabilization fund, or increasing discretionary authority in the operation of the fund.

Perhaps the most compelling solution to these possible contradictions is to use the stabilization fund as a tool for fiscal discipline using strict contingent rules, without bestowing any discretionary authority to the executive branch. As we mention before, for this to be successful, it may also require complementary fiscal rules to prevent the circumvention of the fund. The discretionary power to make adjustments in the effective performance of the fund could be left in the hands of the Central Bank. This could include sterilizing foreign capital flows to avoid the neutralization of the fund objectives. The Central Bank could also allocate the portfolio of the fund between foreign and domestic assets to balance the volatility reduction objectives of the fund with monetary policy and other macroeconomic goals. Another possibility that would create even larger discretionary for the Central Bank would be to grant it the latitude to liquidate assets from the stabilization to pay down the national debt. The implication of this is that as long as fund activity is linked to the size of the fund, the actions of the Central Bank would then have a direct impact on the size of deposits into the fund, and hence an impact on the government budget.

5. CONCLUSIONS AND EXTENSIONS

Using a general equilibrium model, we assess the effectiveness of the Venezuelan stabilization fund in reducing macroeconomic volatility in the presence of price shocks in international oil markets, and contrast the results with two other configurations of the stabilization fund. We find that the FIEM does not perform well in reducing volatility, while the alternative stabilization funds rules described in this paper perform much better. While the FIEM tends to increase volatility in most macroeconomic indicators, the alternative fund models reduce volatility in most of the volatility indicators tested here, including the real exchange rate, GDP growth, consumption growth and investment growth. The decreased volatility does require accumulating more resources in the stabilization fund. We do find, however, that the reduction in macroeconomic volatility resulting from the fund activity does not necessarily translate into less volatility in producer prices for all sectors of the economy. The tradeable sector experiences less volatility, while the non-tradeable sector suffers from higher volatility, both for positive and negative price shocks. For the petroleum sector, the stabilization fund reduces petroleum sector revenue volatility if measured in dollars, while in domestic currency revenue is more volatile.

The results of the analysis presented in this paper suggest that there are tradeoffs in reducing macroeconomic volatility among different indicators such as growth, the real exchange rate, consumption, investment and producer prices. In considering the rules for a stabilization fund, policy makers will need to set priorities in reducing volatility amongst different indicators and sectors. Similarly, income distribution between different segments of Venezuelan society will be impacted differently by volatility and efforts to reduce volatility, adding another important consideration in managing a stabilization fund.

A number of important factors in assessing the performance of the stabilization fund have not been incorporated into this analysis, principally financial variables and the influence of endogenous foreign capital flows. These are topics for further research.

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APPENDIX 1. OIL-RELATED FISCAL STRUCTURE IN VENEZUELA

Currently in Venezuela, oil-related fiscal income capture takes place through three basic channels: royalties, profit taxes, and since 1995, dividends disbursed by Petróleos de Venezuela S. A. (or PDVSA, pronounced pay-day-BAY-sah), the state-run oil company. This appendix explains these elements and their application in detail, relying mainly on the exposition of Ramón Espinasa[12] and the text of the 1999 Profit Tax Law.[13] Table A.1 summarizes the current structure of Venezuela's oil-related fiscal regime.

Table A.1.1.

Current oil-related fiscal structure in Venezuela

Area	Royalty	Profit Taxes	Dividends	Others
PDVSA	1/6 of gross income	67.7%* (income-costs-depreciation-royalty) - 8%*(investments made in the country)-4%(investments in drilling, exploration, and associated installations)	At the discretion of the executive branch	▪ Minor taxes outlined in the Hydrocarbons Law (Ley de Hidrocarburos)
Integrated super-heavy crude projects	1% for the first nine years; 1/6 thereafter	34%* (income-costs-depreciation-royalty)-8%*(investments made in the country)-4%(investments in drilling, exploration, and associated installations)	N.A.	▪ Minor taxes outlined in the Hydrocarbons Law (Ley de Hidrocarburos)
Partnerships ("*Convenios Operativos*")	1%	34%* (income-costs-depreciation-royalty)-8%*(investments made in the country)-4%(investments in drilling, exploration, and associated installations)	N.A.	▪ Minor taxes outlined in the Hydrocarbons Law (Ley de Hidrocarburos) ▪ Bonds tendered
Exploration-at-risk agreements	Variable; up to 1/6 depending on profits	34%* (income-costs-depreciation-royalty)-8%*(investments made in the country)-4%(investments in drilling, exploration, and associated installations)	N.A.	▪ Minor taxes outlined in the Hydrocarbons Law (Ley de Hidrocarburos) ▪ State Profit-Sharing (*Participacion del Estado en las Ganacias*, or PEG): Claim on up to 50% of after-tax income
Orimulsion® projects	Reduction in selling price	34%* (income-costs-depreciation-royalty)-8%*(investments made in the country)-4%(investments in drilling, exploration, and associated installations)	N.A.	

Venezuela's oil-related fiscal structure is marked by heterogeneity and idiosyncratic treatment of different activities. For example, the tax burdensome strategic partnerships for super-heavy crude production or exploration-at-risk are quite different from those borne by PDVSA. A natural implication is that resource allocation within the oil sector depends on the fiscal situation. The existing

[12] Ramón Espinasa, 1999, "El marco fiscal petrolero venezolano: evolución y propuestas," Revista BCV, Foros 3.

fiscal structure punishes PDVSA in the sense that only through partnerships can it enjoy the tax relief granted to super-heavy crude and offshore gas projects.

A.1.1. Royalties

Royalties are not uniform for all petroleum production. Currently they have the following structure:

- 1/6 from PDVSA, which represents the bulk of production;
- One percent of integrated super-heavy crude projects for the first 9 years and 1/6 thereafter;
- Variable, but up to 1/6 from exploration-at-risk agreements not yet engaged in commercially viable production, depending on profits;
- One percent in five partnerships ("*Convenios Operativos*"), and
- Reduction in selling price for the purposes of calculating royalties applicable to Orimulsion® projects.

In the case of PDVSA, the royalty calculation is based not on profits but rather on gross revenues—regardless of the costs incurred to generate them. The formula is:

$$R = 1/6 * (p * v)$$

Where,

R: Royalty

p: Price

v: Volume

Since the royalty takes a fraction of revenue rather than profits, fiscal capture of profits is proportionally larger in areas or projects with greater relative costs. In the case of crudes with similar production costs but different levels of quality and therefore selling price, the marginal royalty rate is higher on the lower-quality product. As the price rises and cost is a smaller fraction of revenue, fiscal capture tends asymptotically towards the royalty rate.

[13] Ley de Impuesto sobre la Renta, Gaceta oficial Extraordinario Nº 5390, October 22, 1999.

For this reason, fiscal capture by royalty is regressive. That is, one might expect that greater profits would be more heavily taxed, and that marginal fiscal capture would diminish as profits declined. But this is not how it works.

Royalties also act as barriers to entry. Being independent of cost, royalties can turn profitable projects into unprofitable ones, diverting investment into sectors of the economy with a lower fundamental profitability but which bear no royalty burden.

A.1.2. Profit taxes

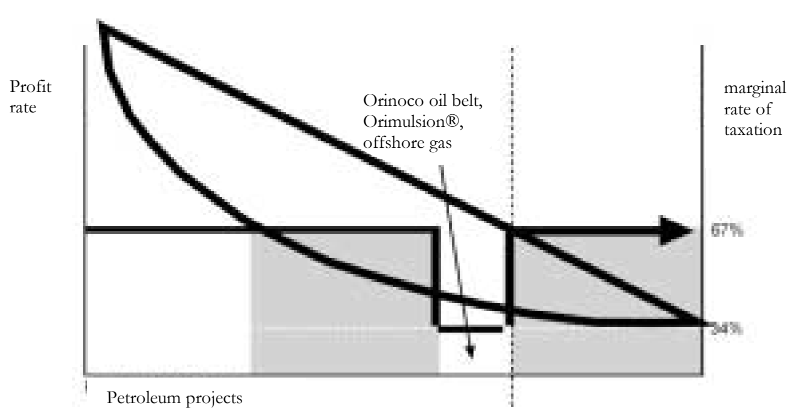
The Profit Tax Law (*Ley de Impuesto sobre la Renta*) governs taxation of all earnings derived from petroleum-related activities such as refinery, transport, and export of associated and derivative products. The profit tax does not apply equally to all branches of petroleum-related activity. Its current rules are as follows:

- 67.7% on the bulk of production, controlled by PDVSA.
- 34% on integrated projects associated with super-heavy crude, offshore gas, and Orimulsion®, which are specifically exempted from the 67.7% tax.

Figure A.1.1. illustrates how the profit tax is thus divided into two different rates according to the type of project.

Figure A.1.1.

The fiscal framework for Venezuelan oil



Source: *Revista BCV* / Foros 3 / 1999

The Profit Tax (PT) is calculated by multiplying the respective rate by net profits, which are figured as the difference between revenue and costs, depreciation, investment, and royalties:

PT = Rate * (Revenue – Costs – Depreciation – Royalties – Investment)

Lastly, it is important to point out that the Profit Tax is proportional to profits—thereby resulting in a lesser degree of risk transfer between the State and the investor while at the same time promoting capital-intensive projects.

A.1.3. PDVSA's dividend policy

In a broad sense, the fiscal framework comprises also the divided policy of PDVSA, which is discretional and subject to the Commercial Code.

A.1.4. Other taxes

Other specific taxes refers to two additional forms of taxation:

- **State Profit-Sharing Bonds** (*Participación del Estado en las Ganancias*, or PEG), established in the Exploration-at-Risk Contracts capture up to half of after-tax net profits, and
- **Bonds Tendered** (*Bonos por Licitación*), which are paid during bidding for partnership agreements (”*convenios operativos*”).

APPENDIX 2. LEGAL FRAMEWORK FOR THE MACROECONOMIC STABILIZATION INVESTMENT FUND (FIEM)[14]

The Macroeconomic Stabilization Investment Fund Law was passed on November 5, 1998. The stated objective of the law is that of "preventing fluctuations in petroleum-related income from affecting the country's necessary fiscal, exchange rate, and monetary balance."[15] Although this goal has remained unchanged, the law has been changed twice since its initial passage—an initial reform on June 14, 1999, and again more recently in October 2001. It could be said that the legal framework has experienced a high degree of volatility during the three years it has been in force. The text below details the principal articles that define the Fund as well as the changes that have been introduced. It includes a brief analysis of the Law's most relevant characteristics, in order to compare the Fund's actual performance with than foreseen in the legal framework.

A.2.1. Original legal framework of the Fund

Contributions that the Republic, state-run agencies, and PDVSA must make to the Fund include:

a) Income from Profit Taxes on petroleum exploitation revenues deemed to exceed the average of those revenues during the past five calendar years.

b) Income from gas and oil exploitation taxes deemed to exceed the average of those revenues during the past five calendar years.

c) Income from dividends decreed and paid by PDVSA, received in excess of the average of those revenues during the past five calendar years.

d) Income from Profit Taxes on PDVSA and its subsidiaries, derived from paid-up capital from companies qualified to participate in international bidding, from tie-breaking bonuses offered and paid by the winning companies, from profit-sharing agreements (PEG) based on a percentage offered by investors, and from other similar sources.

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14 Fasano (2000) reviews the experiences of stabilization funds in various petroleum-exporting countries. Engel and Meller (1992) discuss external shocks and stabilization mechanisms with relation to several different products and Latin American countries, including Venezuela. Hausmann and Powell (1990) review the case for a petroleum stabilization fund in Venezuela and go on to discuss its key characteristics.

15 The text of the law reads: "…procurar que las fluctuaciones del ingreso petrolero no afecten el necesario equilibrio fiscal, cambiario y monetario del país".

The above contributions must be made only after the deduction of: required transfers from the national government to the states, other sums that must be transferred to the States according to the Special Economic Allocation Law (*Ley de Asignaciones Económicas Especiales*), and that portion of income which must be transferred to the Public Debt Rescue Fund by law (*Ley Orgánica de Creación del Fondo de Rescate de la Deuda Pública de Venezuela*).

Income derived from petroleum-related moneys earmarked for state agencies by standard revenue-sharing channels or by 'special economic allocation' must be transferred to the FIEM.

PDVSA must keep in the Fund any income derived from export of petroleum or its derivatives (after subtracting only the relevant taxes) that is due to an increase in the export price relative to its average during the previous five calendar years. PDVSA must also keep in the Fund any extraordinary income it receives, after subtracting the corresponding Profit Tax.

The national executive and PDVSA must analyze, in the first thirty days of each quarter, whether or not revenues in the preceding quarter exceed the established parameters. If so, the appropriate sum must be transferred to the Fund within 60 days of the end of the aforementioned thirty-day period. In the case of extraordinary income, the transfer must occur within the 60 days immediately following realization of the income.

The rules governing withdrawal and use of the Fund's resources are as follows:

When estimates of income to be received by the Republic are revised due to the following causes:

a) Declines in income through the Profit Tax, from taxpaying entities involved in petroleum product exploitation, relative to the average income collected during the five previous calendar years.

b) Declines in income from gas and oil exploitation taxes, relative to the average income collected during the five previous calendar years.

The Fund will transfer to the National Treasury the difference between the income to be collected and the average of the same during the preceding five calendar years. Of this amount, up to 40% must be dedicated to the Unified Social Fund (*Fondo Unico Social* or FUS).

The Fund shall transfer resources to the appropriate state agency when the estimated incomes of those agencies are revised for any of the following reasons:

a) Declines in national-government-to-state-government transfers of petroleum-related income to the Republic due to changes in the petroleum profit tax, with respect to the average of that income during the preceding five calendar years.

b) Declines in national-government-to-state-government transfers of petroleum-related income to the Republic due to changes in the petroleum and gas exploitation tax, with respect to the average of that income during the preceding five calendar years.

c) Declines in 'special economic allocation' income with respect to the average of that income during the preceding five calendar years.

Similarly, the Fund will transfer foreign exchange to PDVSA when, by decision of its Board, there is a revision in estimated income from the export of petroleum and its derivatives due to a decline in the export prices of those products with respect to the average export price in the preceding five years.

Withdrawals from the Fund shall not exceed two thirds of the Fund's balance at the close of the preceding budget period.

Whenever the Fund's total resources exceed 80% of the average value of petroleum exports during the preceding five years, the excess amount will be distributed in the following fashion:

a) From the part corresponding to the Republic, 40% will go to the Unified Social Fund (FUS), 25% to the Venezuelan Public Debt Rescue Fund, and 25% to the Venezuelan Investment Fund.

b) That portion corresponding to state agencies shall be transferred to directly to those agencies, for the sole purpose of investment spending.

c) That portion corresponding to PDVSA will be transferred to it. Its use will be determined by the President of the Republic in consultation with the Council of Ministers.

Petroleum income based on Profit Taxes, royalties, and dividends from the budget package must be made based on average income during the preceding five years. This may result in a lower estimate, but must take into account the Fund's available resources.

A.2.2. The 1999 reform

During a period extending from the Fund's original creation through the year 2004, a temporary provision governs flows into and out of the Fund not according to the aforementioned standard of "average during the preceding five years" but rather according to the following calculations:

a) US$ 420,000,000 as the average income from the Profit Tax on petroleum.

b) US$ 967,000,000 as the average income from the tax on oil and gas exploitation.

c) US$ 1,254,000,000 as the average income from PDVSA dividends.

d) US$ 9 as PDVSA's average export price during the preceding five years.

e) US$ 105,000,000 as the average national government income from Profit Taxes destined for the State governments.

f) US$ 323,000,000 as the average income from the oil and gas exploitation tax earmarked for the States or for 'special economic allocation.'

It also contains a provision according to which only a quantity that exceeds the aforementioned parameters by 50% need be transferred to or maintained in the Fund.

Lastly, it establishes that the President of the Republic, in consultation with the Council of Ministers, can authorize use of the Fund's excess income even before the Fund has actually reached the prescribed limit.

A.2.3. The October 2001 reform

In October of 2001 the FIEM Law was modified once again. There were further changes to the required contributions to the Fund in the last quarter of 2001, the year 2002, and the period from 2003 through 2007.

The revision established that between the fourth quarter of 2001 and the fourth quarter of 2002 there would be no contributions to the Fund. For the period from 2003 through 2007 the following rules would govern contributions: 6% of the petroleum-derived fiscal revenue in 2003, 7% in 2004, 8% in 2005, 9% in 2006, and 10% in 2007. Starting in 2008, the rules set out in the original legal framework will be followed. For PDVSA the rules regarding percentages and years are the same, but with reference to petroleum-related exports rather than to fiscal revenue.

A.2.4. Evaluation of the Fund

Evaluating the Fund is no simple task, especially given the changes it has undergone in such a short period of time and because each of these changes has significantly modified the Fund's characteristics. Moreover, after the two latest reforms, the Fund is one thing in some years and another thing in other years. The first point to highlight is therefore the ironic *instability* of the 'stabilization' fund's legal framework. A second important point relates to the objectives of the 1999 reform and the reason for its failure and subsequent modification.

The principal objective of this reform was apparently to force greater savings (due to the low level set for the transitory parameters[16]) and grant the national executive greater control over the eventual use of those savings. The results were, nevertheless, paradoxical:

- On one hand, in spite of contributions during this period being far below what the law required, a large sum was in fact saved—reaching approximately 7% of GDP.

- On the other hand, public sector debt rose by 10% of GDP. In other words, the net effect was that of greater indebtedness rather than an accumulation of net wealth.[17]

Another aspect worth emphasizing is that this debt was incurred on the domestic capital market at a high cost. Thus, although it would have been preferable to utilize the discretion granted to the executive over the use of these resources, the law's restrictions on the composition of that spending appear to have encouraged the accumulation of additional debt.

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16 Petroleum income defined as "normal" for the period 1999-2004 was in fact extremely low. For example, the petroleum-related fiscal income is defined as US$2.641 billion, representing just 3% of GDP, around 3% lower than what was actually received in 1999—which was already low by historical standards. The "normal" Venezuelan oil price is defined as US$9 per barrel, also far below the average price during the preceding five years.

17 This was pointed out by Ricardo Hausmann in a panel discussion on the vulnerability of countries to external shocks, that took place in Boston in March of 2001. Hausmann noted the ineffectiveness of stabilization mechnanisms in the absence of complementary limits on either the expenditures or indebtedness of the government. Without these, the Fund's resources will only be used as collateral for additional borrowing—which appears to be precisely what occurred in Venezuela.

The latest reform appears to have responded precisely to the need for freeing up resources that would otherwise go to the Fund (or that could only be spent in a manner established by law), in the context of a sharp drop in prices and in petroleum-related fiscal income.

The most important trait of the rules governing FIEM contributions between 2003 and 2007 is that the Fund will thereby lose its ability to play any sort of stabilizing role. Instead, a rising proportion of fiscal revenues and petroleum exports will be deposited in the Fund, independently of where in the business cycle the country may find itself.

The reform did nothing to alter rules governing withdrawals from the Fund, meaning that the rules governing contributions to the Fund now bear little relation to those governing their disbursement. This could lead the Fund to experience, during the 2003-2007 period, the rather absurd situation of *simultaneous* deposits and withdrawals.

Another point worth mentioning is the marked lack of coherence between the Fund and budgetary laws. As Vera and Zambrano[18] comment,

> …it must be mentioned that the National Executive is still out of compliance with the Organic Public Sector Financial Administration Law [LOAFSP, Article 192] according to which it must introduce a new bill including both the Macroeconomic Stabilization Fund and the Intergenerational Savings Fund. It should also be pointed out that the October 2001 reform did nothing to bring the FIEM law into harmony with the Constitution nor with the LOAFSP.
>
> In effect, there continues to be no compliance with that part of article 192 of the aforementioned law requiring the Executive to send the National Assembly a bill harmonizing the two legal frameworks. Likewise, the reformed FIEM retains contradictions with the Constitution and the LOAFSP related to the FIEM's varying stabilization goals and the non-discriminatory character that its administrative and operational rules should have.

It should also be pointed out that a bill is being circulated, prepared by the Office of Economic and Financial Advisors to the National Assembly (OAEF), which attempts to reconcile legal framework

[18] Vera, Leonardo and Luis Zambrano, (2001) "Contenido y Alcance de las Nuevas Reglas del Fondo de Inversión para la Estabilización Macroeconómica".

of the FIEM with that of the LOAFSP. The proposed revisions would involve substituting the current law with one based on a substantially different philosophy.

Instead of stabilizing oil revenues, the legal framework of the proposed bill seeks to "guarantee the stability of public spending by national, regional, and municipal governments faced with fluctuations in ordinary income…"[19]

Another aspect worth mentioning is the discretion of the Executive with respect to use of the Fund's accumulated resources. In part because of this, as well as current fiscal difficulties and the short amount of time that has elapsed since the last reform, we are very doubtful that this bill will become law.

A.2.5. Evolution of the FIEM

The Fund's evolution confirms the fears of those who were concerned about the excessive amount of discretion allowed by its legal framework. Table A.2.1 highlights the differences between the Fund's actual performance and how it would have performed under the counterfactual assumption of a strict application of the rules governing deposits and withdrawals.

As the table shows, by the end of 1999 there should have been roughly US$2.178 billion in contributions to the Fund. In 2000, with an average oil price of US$26.28/barrel and a daily export volume of 2.95 million barrels, deposits in the Fund should have been roughly US$7.983 billion—for a total accumulation of US$10.161 billion.

Of course it must be taken into account that, according to the Fund's legal framework, there is a lag of three months between the moment that income is generated and the moment that deposits to the Fund are realized. Furthermore, the October 2001 legal reform did serve to suspend further deposits to the Fund in the fourth quarter of that year. Nevertheless, it is difficult to understand how—as of November 2001—cumulative deposits to the Fund could have reached only US$6.761 billion.

[19] The bill's text reads, "....garantizar la estabilidad de los gastos a nivel nacional, regional y municipal, frente a las fluctuaciones de los ingresos ordinarios...".

Table A.2.1.
Estimated contributions to the FIEM (US$ Millions)*

	1999	2000	2001
Oil-Related Fiscal Contribution			
Profit Tax	1851	5414	3244
Royalty	1734	4717	3939
Dividends	1381	1466	4688
Transitory FIEM parameters			
Profit Tax	420	420	420
Royalty	967	967	967
Dividends	1254	1254	1254
Portion of Profit Tax Shared with State Governments	105	105	105
Portion of Royalty Shared with State Governments	323	323	323
PDVSA income (at US$9 per barrel)	8870	9691	9855
Oil-Related Parameters			
Average Price (US$/barrel)	16,1	26,28	20
Export Volume (millions of barrels)	2,7	2,95	3,0
Oil Export Income	15867	28297	21900
Net Income from PDVSA's Fiscal Contribution	10901	16700	10029
Contributions to the FIEM			
Republic	707	3061	3248
PDVSA	1016	3505	87
State Governments	456	1417	1367
Overall balance of the FIEM (*assuming strict application of law*)	**2178**	**10161**	**14863**
Actual effective balance of the FIEM**	**2178**	**4460**	**6761**

(*) Calculations for 1999 and 2000 are made based on observed values. Calculations for 2001 are made based on estimated values as of November of that year and extrapolating to the entire year, that is, without taking into account the suspension of fourth-quarter Fund deposits due to the October 4, 2001 legal reform.

(**) The term "effective balance" refers to the cumulated value of deposits to the Fund and does not include income from the Fund's own financial investments. The balance for the year 2001 corresponds to the month of November.

Source: BCV (http://www.bcv.org.ve).

APPENDIX 3. LONG-TERM BEHAVIOR OF OIL PRICES IN VENEZUELA

This appendix addresses the small-sample difficulties of establishing stationarity or unit roots in time series data on oil prices. The analysis follows Pindyck (1999) and the application to the Venezuelan case follows Rigobón (1999).

The appendix is structured as follows. First, it presents a descriptive analysis of WTI (West Texas Intermediate) oil price series in 1999 US dollars, for the period 1870-1996, and compares the result with a Venezuelan oil price series (also in 1999 US dollars) for the period 1950-1996. Second, it compares the results of Dickey-Fuller tests on the two series and explains why they fail to reject the hypothesis of a unit root when the sample is not sufficiently large. Lastly, it estimates a Kalman Filter model with dynamic parameters in order to forecast oil prices on the long term.

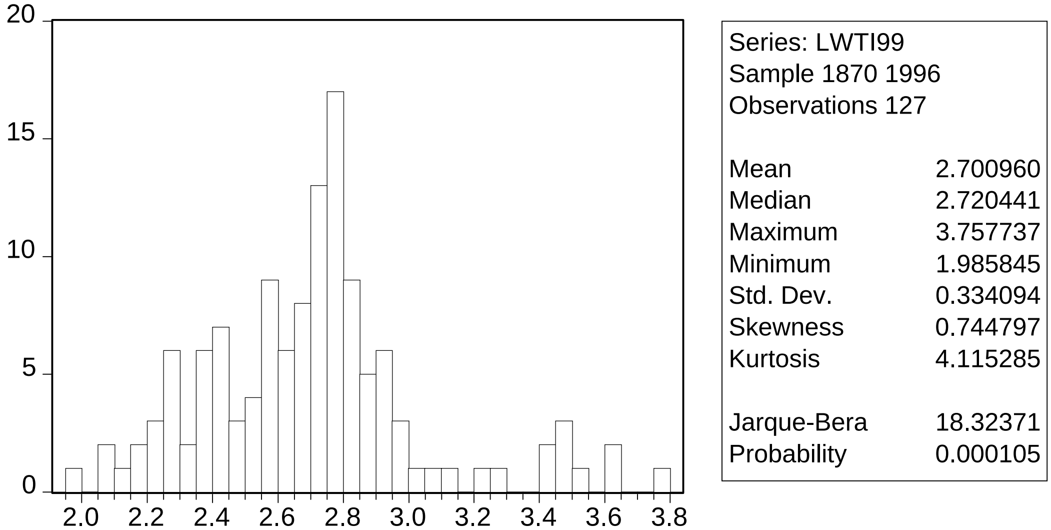
A.3.1. Analysis of the oil price series

The following figure presents a series on the logarithm of real WTI oil prices (in 1999 US$), deflated by a United States wholesale price index.[20] Traditionally, such analyses are performed in logs rather than levels for two reasons. First, the variable in levels can only take positive values, requiring restrictions to be placed on shocks so that they do not generate negative prices. Second, working with logs clarifies interpretation of the results, since a first difference in logs corresponds approximately to a growth rate.

[20] We focus on the *real* price series, as the stochastic behavior of inflation is beyond the scope of this study.

Figure A.3.1.

Logarithm of the real price of WTI oil, 1870-1996 (in 1999 US$)



Since the figure is in logs, the given values for mean, median, maximum and minimum must be transformed (at 1999 prices) in order to give a better idea of what they actually represent. After transformation, we have that the mean and median on this period are US$14.89 and US$15.18 respectively. The maximum, reached in 1981, is US$42.85. The minimum value of US$7.29 was reached in 1910. More important than these values, however, is the non-normality of the distribution as revealed by a Jarque-Bera test.[21]

This is reflected in the larger number of observations to the left of the mean value than to the right (the distribution is skewed to the left), which can be taken to mean that negative shocks are more common than positive ones. It can also be seen in the sharp spike in the distribution (excessive kurtosis, compared to a normal distribution, whose kurtosis is equal to 3), indicating smaller shocks than would be seen in a normal distribution.

The following figure presents the same results for a combined index of Venezuelan real oil price series, in 1999 US dollars, also deflated by a United States wholesale price index.

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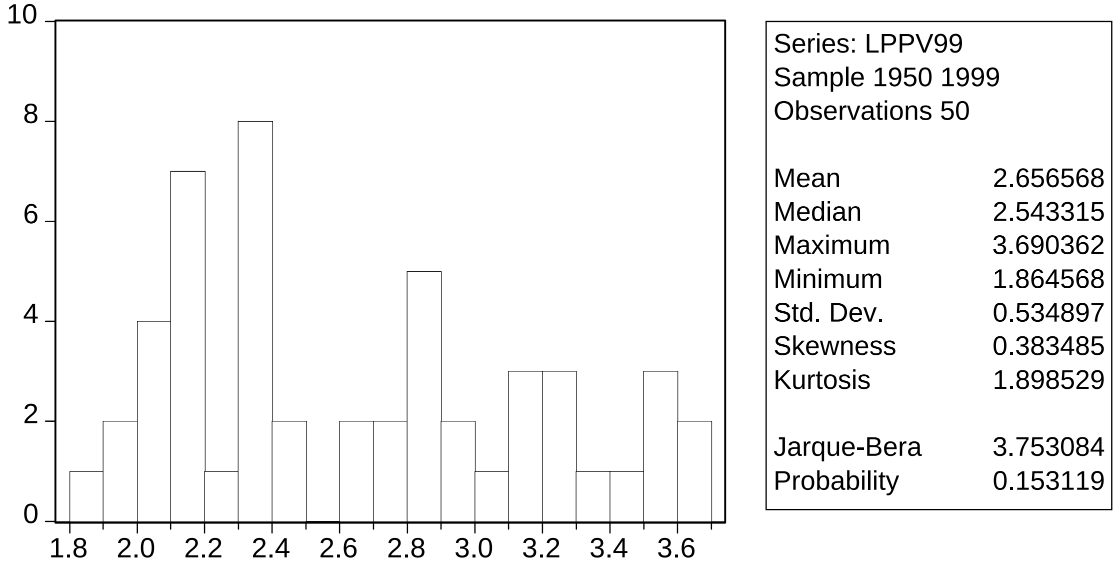
[21] The Jarque-Bera statistic is defined as: $JB = \frac{N-k}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right)$. The values of skewness (*S*) and kurtosis (*K*) are 0 and 3 respectively, in the case of a normally-distributed variable, which produces $JB = 0$.

Figure A.3.2.

Logarithm of real Venezuelan oil prices, 1950-1999 (in 1999 US$)



The mean, maximum, and minimum of the Venezuela series are US$14.24, US$40.01, and US$6.45 respectively. The maximum was reached in 1970, and the minimum in 1981.

It is interesting to note that, despite the non-normal appearance of the distribution plot, the value of the Jarque-Bera statistics is closer to that of a normal distribution than is the same statistic for the WTI price series. Even more interesting is the fact that, although the Venezuelan series is also skewed to the left, it is less so than the WTI distribution. Kurtosis, in turn, is notably lower—lower, in fact, than that of a normal distribution—implying greater volatility in Venezuelan prices than in the WTI series. These conclusions must remain tentative, however, due to the different sample periods for the two series.

A.3.2. Stationarity of the oil price series and unit root test

The above descriptive statistics allow only a first approximation of the behavior of the oil price series. Another technique used to describe the properties of such series is unit root analysis. Put simply, a unit root test seeks to determine whether a series is stable (stationary), or tends to rise (or fall) without bound and in a way not explained by a deterministic trend (unit root). It is of particular interest to establish, when the series is stable or stationary, how long it takes to revert to its mean or trend after a shock occurs. But before we analyze the result of this test for Venezuelan data we must dwell on a fundamental aspect of its application: the low power of the test when used on small samples.

Identifying the stationarity or unit root of a variable requires a rather long time series, as Froot and Rogoff (1995) have discussed in their analysis of exchange rates and Pindyck (1999) in his work on the long-term evolution of oil price behavior. This can be illustrated with the following AR(1) process:

$$X_t = \rho X_{t-1} + e_t$$

where $0 \leq \rho \leq 1$ and e_t is a white noise term. The asymptotic standard deviation of ρ is given by:

$$DS(\rho) = \left[\frac{1-\rho^2}{T}\right]^{1/2}$$

with T equal to the number of observations. The critical value at which a Dickey-Fuller test rejects the null hypothesis H_o: $1 - \rho = 0$ at the 5% significance level is 2.89. The value of T required can be derived from the following expression:

$$T \geq 8.352 \frac{\left(1-\rho^2\right)}{\left(1-\rho\right)^2}$$

Assuming a stationary process taking three years to revert to the mean, ρ must be equal to $(0.5)^{1/3} = 0.79$. Plugging this value into the above expression reveals that the minimum sample size is roughly 73 years, much longer than most reliable time series currently available. If mean reversion is assumed to take place more slowly—say, in five years—then $\rho = 0.87$ and the sample must include at least 120 years.

A.3.3. Results of the test on Venezuelan data

Tables A.3.1 through A.3.3 present an application of the Dickey-Fuller test to an index of Venezuelan crude prices and to WTI crude. For the latter we reproduce the results of Pindyck and Rigobón, to illustrate how their results change if their sample is limited to the years since 1950 rather than the years since 1870. This suggests that something similar might occur in the Venezuelan data if a longer time series were available.

Table A.3.1 presents an application of the test with four lags (in order to test for autocorrelation), with trend and constant terms. The test fails to reject the hypothesis of unit root, even at the 10% significance level. As can be seen in the next table, the same test also fails to reject the unit root hypothesis for WTI data since 1950. When the WTI sample is expanded to the years since 1870, however, the result is markedly different. The unit root hypothesis is rejected in favor of the stationarity of the series, at least at the 10% significance level.

The results shown in Tables A.3.1 through A.3.3 have various implications. First, price shocks are not permanent; we observe reversion to the mean or to a deterministic trend. Second, the optimal design of rules governing stabilization funds must take this behavior into account. Specifically, a determination of the average duration of shocks would allow one to assess the stabilizing effect of a given set of rules governing deposits to and withdrawals from the Fund. Finally, the stationarity of the series allows prediction of its future behavior. Effectively, when a series exhibits a unit root the best predictor of its future value is its current value; its variation is solely due to random and therefore unpredictable shocks. If on the other hand a series is stationary, one can attempt to forecast its evolution. Below we present estimations of two forecasting models, one autoregressive and the other employing a Kalman Filter.

Table A.3.1.

Results of a Dickey-Fuller Test with Four Lags

ADF Test Statistic	-1.720850	1% Critical Value*	-4.1896
		5% Critical Value	-3.5189
		10% Critical Value	-3.1898

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LPPV99)

Method: Least Squares

Date: 07/17/01 Time: 18:37

Sample(adjusted): 1955 1996

Included observations: 42 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPPV99(-1)	-0.159873	0.092903	-1.720850	0.0941
D(LPPV99(-1))	0.122148	0.166620	0.733095	0.4684
D(LPPV99(-2))	0.126238	0.167993	0.751452	0.4574
D(LPPV99(-3))	0.197966	0.168392	1.175629	0.2477
D(LPPV99(-4))	-0.092542	0.168159	-0.550324	0.5856
C	0.316154	0.189386	1.669370	0.1040
@TREND(1950)	0.004853	0.004023	1.206376	0.2358

R-squared	0.122976	Mean dependent var	0.014430
Adjusted R-squared	-0.027371	S.D. dependent var	0.212599
S.E. of regression	0.215488	Akaike info criterion	-0.080807
Sum squared resid	1.625235	Schwarz criterion	0.208805
Log likelihood	8.696943	F-statistic	0.817947
Durbin-Watson stat	1.945705	Prob(F-statistic)	0.563507

Table A.3.2.

Results of a Dickey-Fuller Test on WTI Crude Prices

ADF Test Statistic	-2.24565	1% Critical Value*	-4.1630
		5% Critical Value	-3.5066
		10% Critical Value	-3.1828

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LWTI99)

Method: Least Squares

Date: 07/17/01 Time: 18:40

Sample: 1950 1996

Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LWTI99(-1)	-0.301675	0.134337	-2.245650	0.0303
D(LWTI99(-1))	0.153221	0.170891	0.896601	0.3753
D(LWTI99(-2))	0.197482	0.164745	1.198716	0.2377
D(LWTI99(-3))	0.022931	0.165520	0.138541	0.8905
D(LWTI99(-4))	0.002457	0.162257	0.015142	0.9880
C	0.810167	0.356975	2.269538	0.0287
@TREND(1950)	0.002852	0.002333	1.222346	0.2287

R-squared	0.149067	Mean dependent var	0.003015
Adjusted R-squared	0.021427	S.D. dependent var	0.166044
S.E. of regression	0.164256	Akaike info criterion	-0.638178
Sum squared resid	1.079200	Schwarz criterion	-0.362624
Log likelihood	21.99718	F-statistic	1.167867
Durbin-Watson stat	1.987918	Prob(F-statistic)	0.342620

Table A.3.3.

Results of a Dickey-Fuller Test on WTI prices since 1870

ADF Test Statistic	-3.212593	1% Critical Value*	-4.0355
		5% Critical Value	-3.4469
		10% Critical Value	-3.1482

*MacKinnon critical values for rejection of hypothesis of a unit root.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LWTI99)
Method: Least Squares
Date: 07/17/01 Time: 18:44
Sample(adjusted): 1875 1996
Included observations: 122 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LWTI99(-1)	-0.235388	0.073270	-3.212593	0.0017
D(LWTI99(-1))	0.081996	0.098403	0.833265	0.4064
D(LWTI99(-2))	-0.061654	0.085886	-0.717859	0.4743
D(LWTI99(-3))	-0.243573	0.082434	-2.954781	0.0038
D(LWTI99(-4))	0.085412	0.085233	1.002096	0.3184
C	0.556494	0.178669	3.114661	0.0023
@TREND(1870)	0.001182	0.000560	2.109758	0.0370

R-squared	0.222936	Mean dependent var	0.004984
Adjusted R-squared	0.182394	S.D. dependent var	0.194789
S.E. of regression	0.176131	Akaike info criterion	-0.579510
Sum squared resid	3.567552	Schwarz criterion	-0.418624
Log likelihood	42.35012	F-statistic	5.498830
Durbin-Watson stat	1.984927	Prob(F-statistic)	0.000049

A.3.4. An autoregressive model

A very simple model for estimating crude price behavior is the first-order autoregressive model with trend and constant terms, presented in the following table. Note that the statistical significance of the trend term is very low; it is nevertheless included for theoretical reasons.[22] In general, the model has good explanatory power, with a coefficient of determination of 85%. It is true, however, that an analysis of the residuals with a Jarque-Bera test reveals their non-normality, with a large degree of skewness and kurtosis (Figure A.3.3).

[22] Strictly speaking, Pindyck (1978, 1980) shows that a quadratic (U-shaped) trend is consistent with nonrenewable resource production models that incorporate exploration and accumulation of proven reserves over time as well as technological change. Nevertheless, better results were obtained in the present case using a linear rather than a quadratic term. This may be due to omission from the sample of the years 1920-1950, a period of declining prices.

Table A.3.4.

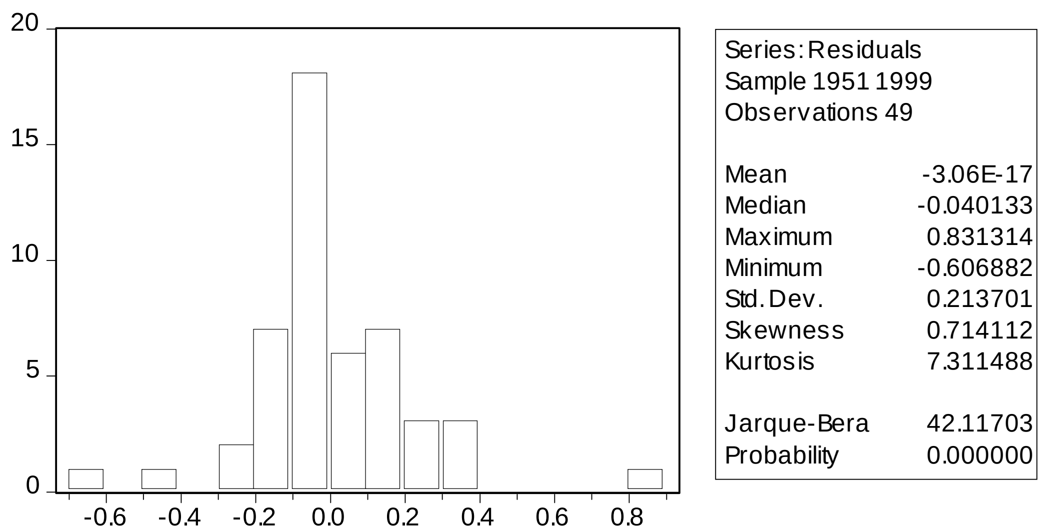
Results of the Autoregressive Model

Dependent Variable: LOG(PPV99)
Method: Least Squares
Date: 06/04/01 Time: 10:53
Sample(adjusted): 1951 1999
Included observations: 49 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.272115	0.163805	1.661213	0.1035
@TREND(1950)	0.002053	0.002717	0.755780	0.4536
LOG(PPV99(-1))	0.881647	0.071861	12.26880	0.0000
R-squared	0.842332	Mean dependent var		2.663466
Adjusted R-squared	0.835477	S.D. dependent var		0.538189
S.E. of regression	0.218297	Akaike info criterion		-0.146650
Sum squared resid	2.192066	Schwarz criterion		-0.030824
Log likelihood	6.592925	F-statistic		122.8762
Durbin-Watson stat	1.934607	Prob(F-statistic)		0.000000

Figure A.3.3.

Autoregressive Model



A.3.5. Kalman Filter model to estimate behavior of the Venezuelan oil price index

The aforementioned work of Pindyck (1999), based on the Hotelling model of nonrenewable resources sold in a competitive market at the marginal extraction cost, concludes that any model seeking to explain the long-term evolution of crude prices must include the following characteristics: 1) long-term reversion to an unknown total marginal cost that follows some trend, and 2) continuous fluctuation in the slope and intercept of that trend. Given these traits, the model should take the following form:

$$p_t = \rho p_{t-1} + \beta_1 + \beta_2 t + \beta_3 t^2 + \phi_{1t} + \phi_{2t} t + \varepsilon_t$$
$$\phi_{1t} = \alpha_1 \phi_{1,t-1} + v_{1t}$$
$$\phi_{2t} = \alpha_2 \phi_{2,t-1} + v_{2t}$$

where ϕ_1, ϕ_2 are unobserved state variables.

As can be seen in the above expressions, both the independent terms and the trend have a fixed component and a random component. A Kalman Filter allows estimation of the former of the two. This procedure uses maximum likelihood to estimate the parameters together with optimal estimates (in mean square error) of the state variables.

The following table presents results of an application of this method to Venezuelan data. This model obviously differs in some respects from that estimated by Pindyck. First of all, it includes no quadratic term—which was found insignificant for reasons discussed above under the autoregressive model estimation. Secondly, the state variables utilize nonstationary processes, since the expression suggested by Pindyck does not result in convergence in this case. Note, however, the similarity between the results produced by the Kalman Filter and those from the autoregressive model. In both cases the constant term is roughly 0.27. Furthermore, summing the final values for SV1 and SV2 with C(2) and C(3) respectively gives approximately the same values for these coefficients as in the autoregressive model. This is reflected in the projections made by both models.

Table A.3.5.

Results of the Kalman Filter model

SSpace: FSRV
Estimation Method: Maximum Likelihood
Date: 06/04/01 Time: 12:08
Model: Time-Varying Coefficient Model
Sample(adjusted): 1951 1999
Included Observations: 44
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence not achieved after 100 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.278425	0.315406	0.882750	0.3832
C(2)	0.001043	0.006858	0.152024	0.8800
C(3)	-0.110349	0.097883	-1.127356	0.2671
OBVAR(1,1)	0.049052	0.017086	2.870965	0.0068
SSVAR(1,1)	1.76E-11	96883567	1.81E-19	1.0000
SSVAR(2,2)	5.05E-09	414846.4	1.22E-14	1.0000
Final SV1	0.000881	0.002027	0.434462	0.6665
Final SV2	0.991360	0.021916	45.23487	0.0000
Log Likelihood		3.780293		

LOG(PPV99) = C(1) +(SV1+C(2))*@TREND(1950) +(SV2+C(3)) *LOG(PPV99(-1))
SV1 = SV1(-1)
SV2 = SV2(-1)

R-squared	0.840220	Mean dependent var	2.702537
Adjusted R-squared	0.832425	S.D. dependent var	0.554262
S.E. of regression	0.226892	Sum squared resid	2.110678
Durbin-Watson stat	1.894440		

The below table and figure reveal the similarity between forecasts made using the two models. It is interesting to note, in the various scenarios, convergence toward a common long-term trend.

Table A.3.6.

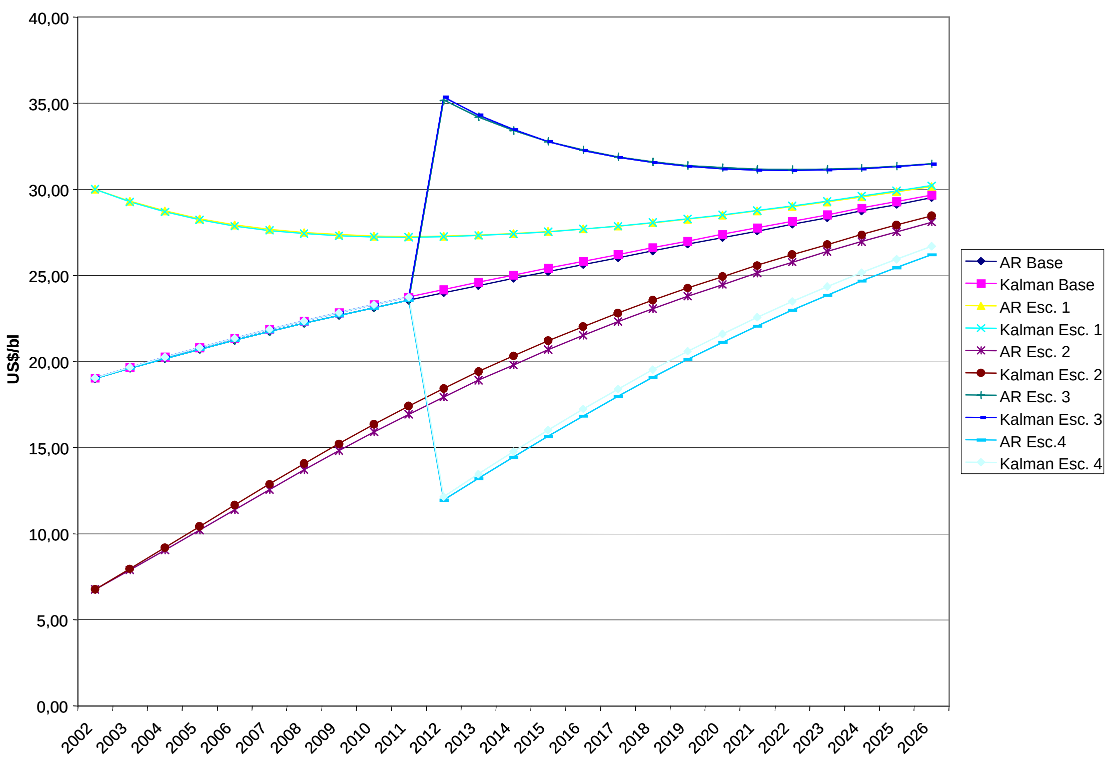
Venezuelan crude price index projections (1996 US$/barrel)

	Base		Escenario 1		Escenario 2		Escenario 3		Escenario 4	
	AR	Kalman	AR	Kalman	AR	Kalman	AR	Kalman	AR	Kalman
2002	19,00	19,04	30,00	30,00	6,77	6,77	19,00	19,04	19,00	19,04
2003	19,59	19,66	29,29	29,26	7,89	7,96	19,59	19,66	19,59	19,66
2004	20,16	20,25	28,73	28,68	9,05	9,18	20,16	20,25	20,16	20,25
2005	20,70	20,82	28,28	28,22	10,22	10,42	20,70	20,82	20,70	20,82
2006	21,22	21,35	27,93	27,87	11,40	11,65	21,22	21,35	21,22	21,35
2007	21,72	21,87	27,67	27,61	12,56	12,87	21,72	21,87	21,72	21,87
2008	22,20	22,36	27,48	27,42	13,70	14,07	22,20	22,36	22,20	22,36
2009	22,67	22,84	27,35	27,30	14,82	15,22	22,67	22,84	22,67	22,84
2010	23,12	23,30	27,28	27,23	15,90	16,34	23,12	23,30	23,12	23,30
2011	23,56	23,74	27,26	27,22	16,94	17,41	23,56	23,74	23,56	23,74
2012	23,99	24,18	27,28	27,24	17,94	18,43	35,17	35,36	11,94	12,13
2013	24,41	24,60	27,34	27,31	18,90	19,40	34,19	34,30	13,21	13,45
2014	24,82	25,01	27,43	27,41	19,81	20,32	33,40	33,46	14,45	14,75
2015	25,23	25,42	27,54	27,53	20,68	21,19	32,77	32,79	15,66	16,02
2016	25,63	25,82	27,69	27,69	21,51	22,02	32,27	32,26	16,84	17,24
2017	26,02	26,21	27,86	27,87	22,30	22,81	31,88	31,85	17,97	18,41
2018	26,41	26,60	28,05	28,07	23,06	23,55	31,59	31,55	19,07	19,53
2019	26,80	26,99	28,26	28,28	23,78	24,26	31,38	31,33	20,11	20,59
2020	27,19	27,37	28,49	28,52	24,47	24,94	31,24	31,19	21,11	21,60
2021	27,58	27,76	28,73	28,77	25,13	25,58	31,16	31,11	22,07	22,57
2022	27,96	28,14	28,99	29,03	25,76	26,20	31,14	31,09	22,98	23,48
2023	28,35	28,52	29,26	29,31	26,37	26,79	31,17	31,12	23,84	24,34
2024	28,73	28,90	29,55	29,60	26,96	27,36	31,24	31,19	24,67	25,16
2025	29,12	29,28	29,85	29,90	27,53	27,92	31,34	31,30	25,46	25,94
2026	29,50	29,66	30,15	30,21	28,08	28,45	31,48	31,45	26,21	26,68

Source: Authors' calculations.

Figure A.3.4.

Venezuelan crude price index projections



The scenarios at 1996 prices, for the period 2002-2026, are as follows:

1. Base scenario, which assumes convergence to the long-term trend with no shocks.

2. Positive shock, equivalent to one standard deviation in prices, in the year 2002. The standard deviation is calculated using the Venezuelan price index for the period 1950-2001 and equals US$11.62/barrel.

3. Negative shock, equivalent to one standard deviation in prices, in the year 2002.

4. Positive shock, equivalent to one standard deviation in prices, in the year 2012 (the middle of the time horizon in question).

5. Negative shock, equivalent to one standard deviation in prices, in the year 2012.

APPENDIX 4. COMPARISON OF MODEL RESULTS UNDER DIFFERENT INTERNATIONAL OIL PRICE PATHS

Table A.4.1. Aggregate Volatility Indicator Results - Negative price shock

	High price path		Low price path	
	Standard deviation	Mean value	Standard deviation	Mean value
GDP - ALT FUND 2		4968		4725
GDP - ALT FUND 1		4969		4725
GDP - FIEM		5035		4764
GDP - BASE		5070		4794
GDP growth - ALT FUND 2	0.0061	0.029	0.0077	0.025
GDP growth - ALT FUND 1	0.0060	0.029	0.0077	0.025
GDP growth - FIEM	0.0056	0.030	0.0065	0.026
GDP growth - BASE	0.0072	0.030	0.0083	0.026
Exchange rate - ALT FUND 2	0.0684	1.033	0.0770	1.096
Exchange rate - ALT FUND 1	0.0682	1.033	0.0770	1.096
Exchange rate - FIEM	0.0760	1.028	0.0803	1.091
Exchange rate - BASE	0.0883	1.029	0.0940	1.092
Exchange rate growth - ALT FUND 2	0.0419	-0.001	0.0324	-0.004
Exchange rate growth - ALT FUND 1	0.0419	-0.001	0.0324	-0.004
Exchange rate growth - FIEM	0.0634	-0.002	0.0518	-0.005
Exchange rate growth - BASE	0.0795	-0.003	0.0678	-0.006
Government revenue - ALT FUND 2	330	1308	222	1177
Government revenue - ALT FUND 1	330	1309	222	1177
Government revenue - FIEM	374	1357	264	1212
Government revenue - BASE	356	1362	245	1213
Government revenue growth - ALT FUND 2	0.0494	0.039	0.0501	0.031
Government revenue growth - ALT FUND 1	0.0492	0.039	0.0501	0.031
Government revenue growth - FIEM	0.0570	0.041	0.0568	0.034
Government revenue growth - BASE	0.0577	0.041	0.0612	0.033
Consumption growth - ALT FUND 2	0.0077	0.030	0.0059	0.025
Consumption growth - ALT FUND 1	0.0077	0.030	0.0059	0.025
Consumption growth - FIEM	0.0150	0.032	0.0104	0.027
Consumption growth - BASE	0.0154	0.032	0.0114	0.026
Investment growth – ALT FUND 2	0.0276	0.031	0.0264	0.021
Investment growth – ALT FUND 1	0.0271	0.031	0.0264	0.021
Investment growth - FIEM	0.0427	0.033	0.0397	0.024
Investment growth - BASE	0.0485	0.033	0.0487	0.024

Table A.4.2. Aggregate Volatility Indicator Results – Positive Price Shock

	High price path		Low price path	
	Standard deviation	Mean value	Standard deviation	Mean value
GDP - ALT FUND 2		5299		4985
GDP - ALT FUND 1		5308		4992
GDP - FIEM		5385		5055
GDP - BASE		5453		5107
GDP growth - ALT FUND 2	0.0029	0.034	0.0046	0.029
GDP growth - ALT FUND 1	0.0028	0.034	0.0045	0.029
GDP growth - FIEM	0.0036	0.035	0.0046	0.030
GDP growth - BASE	0.0036	0.035	0.0057	0.030
Exchange rate - ALT FUND 2	0.0715	0.938	0.0606	1.033
Exchange rate - ALT FUND 1	0.0721	0.938	0.0612	1.033
Exchange rate - FIEM	0.0786	0.932	0.0694	1.027
Exchange rate - BASE	0.0718	0.934	0.0702	1.030
Exchange rate growth - ALT FUND 2	0.0346	0.000	0.0317	-0.005
Exchange rate growth - ALT FUND 1	0.0397	-0.001	0.0345	-0.005
Exchange rate growth - FIEM	0.0504	-0.001	0.0486	-0.006
Exchange rate growth - BASE	0.0448	-0.001	0.0442	-0.006
Government revenue - ALT FUND 2	533	1519	345	1316
Government revenue - ALT FUND 1	532	1523	345	1319
Government revenue - FIEM	583	1586	390	1365
Government revenue - BASE	543	1597	348	1366
Government revenue growth - ALT FUND 2	0.0528	0.045	0.0502	0.035
Government revenue growth - ALT FUND 1	0.0443	0.045	0.0453	0.035
Government revenue growth - FIEM	0.0538	0.047	0.0546	0.037
Government revenue growth - BASE	0.0447	0.046	0.0481	0.036
Consumption growth - ALT FUND 2	0.0137	0.036	0.0094	0.030
Consumption growth - ALT FUND 1	0.0149	0.036	0.0101	0.030
Consumption growth - FIEM	0.0244	0.038	0.0201	0.031
Consumption growth - BASE	0.0203	0.037	0.0173	0.031
Investment growth – ALT FUND 2	0.0341	0.039	0.0302	0.026
Investment growth – ALT FUND 1	0.0287	0.039	0.0263	0.026
Investment growth - FIEM	0.0429	0.041	0.0425	0.029
Investment growth - BASE	0.0333	0.040	0.0360	0.027

APPENDIX 5. EQUATIONS FOR THE CGE MODEL

Price Block

(1) $P_i^{nm} = pw_i^{nm}\ (1 + t_i^{nm}) RER$

(2) $P^{km} = pw^{km}\ (1 + t^{km}) RER$

(3) $P_i^{sm} = pw_i^{sm}\ (1 + t_i^{sm}) RER$

(4) $P_h^{cm} = pw_h^{cm}\ (1 + t_h^{cm}) RER$

(5) $P_i^{e} = pw_i^{e}\ RER$

(6) $P_i^{x} = \dfrac{P_i^d \cdot D + P_i^m \cdot M}{Q}$

(7) $P_i^{v} \cdot X_i = P_i^{x}\ (1 - tx_i - sub_i)\ X - P_i^{nd} \cdot NTD_i - P_i^{nm} \cdot NTM_i$

(8) PINDEX = GDPVA/RGDP

(9) $P_{pet}^{d} = PINDEX$

(10) $CPI = \sum_h P_h^{ct} \cdot CTT_h / \sum_h CTT_h$

Production Block

(11) $X_{tnt}^{xf} = tfp \cdot a_{tnt}^{xf} (\delta_{tnt}^{xf} \cdot VA_{tnt}^{-\rho_{tnt}^{xf}} + (1 - \delta_{tnt}^{xf}) \cdot NTT_{tnt}^{xf\ -\rho_{tnt}^{xf}})^{-1/\rho_{tnt}^{xf}}$

(12) $X_{tnt} = X_{tnt}^{xf} + \sum_v X_{tnt}^{v}$

(13) $VA_{tnt} = k_{tnt}^{xf\ \alpha_{tnt}^{k}} \cdot \prod_l L_{tnt}^{xf\ \alpha_{tnt}^{l}}$

(14) $P_{tnt}^{va} = (WFD_{tnt}^{k} \cdot r \cdot k_{tnt}^{xf} + \sum_l wfd_l^{tnt} \cdot W_l \cdot L_l^{xf}) / VA_{tnt}$

$$(15)\ VA_{tnt} = NTT_{tnt}^{xf} \cdot \left[\frac{P_{tnt}^{ntf} \cdot \delta_{tnt}^{xf}}{P_{tnt}^{va} \cdot (1-\delta_{tnt}^{xf})} \right]^{\frac{1}{1+\rho_{tnt}^{xf}}}$$

$$(16)\ W_l \cdot wfd_{l.} \cdot L_l^{xf} = P_{tnt}^{xf}\ (1-tx_{tnt}-sub_{tnt}) \cdot \alpha_{tnt}^{l} \cdot \delta_{tnt}^{xf} \cdot tfp_{tnt} \cdot a_{tnt}^{xf\ -\rho_{tnt}^{xf}} \cdot X_{tnt}^{xf\ 1+\rho_{tnt}^{xf}} \cdot VA_{tnt}^{\ -\rho_{tnt}^{xf}}$$

$$(17)\ r \cdot WFD_{.tnt}^{k} \cdot k_{tnt}^{xf} = P_{tnt}^{xf} \cdot X_{tnt}^{xf}\ (1-tx_{tnt}-sub_{tnt}) - P_{tnt}^{ntf} \cdot NTT_{tnt}^{xf} - W_{tnt}^{l} \cdot wfd_{tnt}^{l} \cdot L_{tnt}^{xf}$$

$$(18)\ r \cdot WFD_{.pet}^{kp} \cdot k_{pet} = P_{pet}^{x} \cdot X_{pet}\ (1-tx_{pet}-sub_{pet}) - P_j^{d} \cdot io_{pet}^{ji} \cdot X_{pet} - P_{pet}^{ntm} \cdot NTM_{pet} - W_{pet\cdot}^{l} \cdot wfd_{pet}^{l} \cdot L_{pet}^{l}$$

$$(19)\ P_{tnt}^{x}\ (1-tx_{tnt}-sub_{tnt}) - c_{tnt}^{nd} \cdot P_{tnt}^{nd} - c_{tnt}^{nm} \cdot P_{tnt}^{nm} - \sum_{l} W_{tnt}^{l} \cdot wfd_{tnt}^{l} \cdot L_{tnt}^{v,l} - r_{tnt}^{l} \cdot WFD_{tnt}^{l} \cdot L_{tnt}^{v,l} = 0$$

$$(20)\ K_{tnt}^{xv} = c_{tnt}^{k,v} \cdot X_{tnt}^{v}$$

$$(21)\ L_{tnt}^{xv,l} = c_{tnt}^{l,v} \cdot X_{tnt}^{v}$$

$$(22)\ NTM_{tnt}^{xv} = c_{tnt}^{ntm,v} \cdot X_{tnt}^{v}$$

$$(23)\ NTD_{tnt}^{xv} = c_{tnt}^{ntd,v} \cdot X_{tnt}^{v}$$

$$(24)\ X_{tnt} = a_{tnt}^{e} \cdot (\gamma_{tnt} \cdot E_{tnt}^{\rho_{tnt}^{e}} + (1-\gamma_{tnt}) \cdot D_{tnt}^{\rho_{tnt}^{e}})^{1/\rho_{tnt}^{e}}$$

$$(25)\ E_{tnt} = D_{tnt} \cdot \left[\frac{P_{tnt}^{e} \cdot (1-\gamma_{tnt})}{P_{tnt}^{d} \cdot \gamma_{tnt}} \right]^{\frac{1}{\rho_{tnt}^{e}-1}}$$

Intermediates Block

$$(26)\ INT_i = \sum_j NT_{ij}$$

$$(27)\ INTM = \sum_j NTM_j$$

$$(28)\ NT_{i,tnt} = iof_{i,tnt} \cdot NTD_{tnt}$$

$$(29)\ NT_{i,pet} = iof_{i,pet} \cdot x_{pet}$$

$$(30)\ NTD_{pet} = \sum_{i} NT_{i}$$

$$(31)\ NTM_{pet} = iom_{pet} \cdot x_{pet}$$

$$(32)\ NTM_{tnt}^{tot} = NTM_{tnt}^{xf} + \sum_{v} NTM_{tnt}^{v}$$

$$(33)\ NTD_{tnt}^{tot} = NTD_{tnt}^{xf} + \sum_{v} NTD_{tnt}^{v}$$

$$(34)\ P_{j}^{ntd} \cdot NTD_{j} = \sum_{i} NT_{ij} \cdot P_{i}^{d}$$

$$(35)\ P_{tnt}^{ntf} \cdot NTT_{tnt}^{xf} = P_{tnt}^{nd} \cdot NTD_{tnt}^{xf} + P_{tnt}^{nm} \cdot NTM_{tnt}^{xf}$$

$$(36)\ NTM_{tnt}^{xf} = NTD_{tnt}^{xf} \cdot \left[\frac{P_{tnt}^{ntd} \cdot (1-\phi_{tnt})}{P_{tnt}^{ntm} \cdot \phi_{tnt}} \right]^{\frac{1}{\rho_{tnt}^{ntt}-1}}$$

$$(37)\ NTT_{tnt}^{xf} = a_{tnt}^{ntt} \cdot (\phi_{tnt} \cdot NTM_{tnt}^{\rho_{tnt}^{ntt}} + (1-\phi_{tnt}) \cdot NTD_{tnt}^{\rho_{tnt}^{ntt}})^{1/\rho_{tnt}^{ntt}}$$

Factors Block

$$(38)\ YF_{knp} = \sum_{tnt} r \cdot WFD_{tnt}^{k} \cdot K_{tnt}^{xf} + \sum_{tnt,v} r \cdot WFD_{tnt}^{k} \cdot K_{tnt}^{v}$$

$$(39)\ YF_{kpet} = r \cdot WFD_{pet}^{k} \cdot K_{pet}$$

$$(40)\ YF_{l} = \sum_{l} W \cdot wfd_{i}^{l} \cdot L_{i}^{l,xf} + \sum_{l,v} W \cdot wfd_{i}^{l,v} \cdot L_{i}^{l,v}$$

$$(41)\ K_{tnt}^{tot} = K_{tnt}^{xf} + \sum_{v} K_{tnt}^{v}$$

$$(42)\ W_{l} / CPI = \eta_{l} \cdot (UNEM_{l} / LS_{l})^{\kappa}$$

$$(43)\ FSL_{.} = \sum_{i} L_{i}^{l} + UNEM_{l}$$

$$(44)\ L_{i}^{tot} = L_{i}^{xf} + \sum_{v} L_{i}^{v}$$

Corporations Block

$$(45)\ YCOR_c = \sum_k cyfs_c^k \cdot YFL_k + gtcs_c \cdot GOVY + wtc_c \cdot RER + \sum_c ctcs_{c,cc} \cdot YCOR_{cc}$$

$$(46)\ CORSAV = \sum_{cnp} cmps_{cnp} \cdot YCOR_{cnp} + INV_{pet}$$

Income and Consumption Block

$$(47)\ YH_h = \sum_f hyfs_h^f \cdot YF_f + cths_c^h \cdot YCOR_c + gth_h + wth_h \cdot RER$$

$$(48)\ HSAV_h = hmps_h \cdot YH_h \cdot (1 - tx_h)$$

$$(49)\ CTT_h = YH_h \cdot (1 - tx_h) \cdot (1 - hmps_h - htws_h) / P_h^{ct}$$

$$(50)\ CN_i^h = hcons_i^j \cdot CD_h$$

$$(51)\ CTT_h = a_h^{ctt} \cdot (\lambda_h \cdot CM_h^{\rho_h^{ctt}} + (1 - \lambda_h) \cdot CD_h^{\rho_h^{ctt}})^{1/\rho_h^{ctt}}$$

$$(52)\ CM_h = CD_h \cdot \left[\frac{P_h^{cd} \cdot (1 - \lambda_h)}{P_h^{cm} \cdot \lambda_h} \right]^{\frac{1}{\rho_h^{ctt} - 1}}$$

$$(53)\ P_h^{cd} = \sum_i P_i^d \cdot CN_i^h / \sum_i CN_i^h$$

$$(54)\ P_h^{ct} = (P_h^{cd} \cdot CD_h + P_h^{cm} \cdot CM_h) / CTT_h$$

$$(55) GOVY = \sum_h tx_h \cdot YH_h + \sum_{cnp} tx_{cnp} \cdot YCOR_{cnp} + \sum_h (tx_i + sub_i) \cdot P_i^x \cdot X_i + OILTAXS$$
$$+ TARIFFS + wtg \cdot RER$$

$$(56) GOVSAV = GOVY - \sum_i P_i^d \cdot GD_i - \sum_h gth_h - \sum_c gtc_c \cdot GOVY - gtws \cdot GOVY$$
$$- SFD \cdot RER + SFW \cdot RER$$

$$(57)\ GD_i = gg_i \cdot GOVCON$$

(58) $TARIFF =$

$$(\sum_h CM_h \cdot tcm_h \cdot pwcm_h + IDM \cdot tkm \cdot pwkm + DSTM \cdot tdm \cdot pwdm + \sum_i NTM_i \cdot tnm_i \cdot pwnm_i) \cdot RER$$

(59) $OILTAXS = YCOR_{pet} - \sum_h cths_h^{pet} \cdot YCOR_{pet} - ctws_{pet} YCOR_{pet} - \sum_c ctcs_{c,cc} \cdot YCOR_{pet} - INV_{pet}$

(60) $PTAXS = P_{pet}^x \cdot X_{pet} / 6$

(61) $YTAXS = .67 \cdot cyfs_{pet}^{kp} \cdot YF_{kp} - PTAXS - INV_{pet}$

(62) $DIVS = OILTAXS - YTAXS - PTAXS$

Investment and Inventory Block

(63) $P_{kt} \cdot IDT = FXDINV$

(64) $ID_i = kds_i \cdot IDD$

(65) $P_{kd} \cdot IDD = \sum_i P_i^d \cdot ID_i$

(66) $P_{kt} \cdot IDT = P_{kd} \cdot IDD + P_{km} \cdot IDM$

(67) $IDT = a^{idt} \cdot (\pi \cdot IDM^{\rho^{idt}} + (1-\pi) \cdot IDD^{\rho^{idt}})^{1/\rho^{idt}}$

(68) $IDM = IDD \cdot \left[\frac{P^{kd} \cdot (1-\pi)}{P^{km} \cdot \pi} \right]^{\frac{1}{\rho^{idt}-1}}$

(69) $FXDINV = INVEST - \sum_i DST_i \cdot P_i^d - DST_m \cdot P_{sm}$

(70) $DST_i = dstr_i \cdot X_i$

Macro block

(71) $D_i = INT_i + CD_i^{tot} + GD_i + ID_i + DST_i$

$$(72)\ SAVING = \sum_h HSAV_h + GOVSAV + CORSAV + FSAV \cdot EXR$$

$$(73)\ FSAV \cdot RER = (IDM \cdot pw_{km} + DST_m \cdot pw_{dm} + \sum_h CM_h \cdot pw_{cm} + \sum_c ctws_c \cdot YCOR_c + gtws \cdot GOVY$$

$$- \sum_h wth_h \cdot YH_h \cdot (1 - tx_h) - \sum_i E_i \cdot pw_e - wtg \cdot RER - \sum_c wtc_c + SFD - SFW) \cdot RER$$

$$(74)\ GDPVA = \sum_i P_i^v \cdot X_i + \sum_h (tx_i + sub_i) \cdot P_i^x \cdot X_i + TARIFF$$

$$(75)\ RGDP = \sum_i (CD_i^{cd} + GD_i + DST_i + ID_i + E_i) + \sum_h CM \cdot tx_h^m \cdot pw_h^m + IDM \cdot tx_{km} \cdot pw_{km}$$

$$+ DSTM \cdot tx_{dm} \cdot pw_{dm} - \sum_i NTM_i \cdot pw_i^{nm}$$

Stabilization Fund

$$(76)\ SFUND = sfundi \cdot (1 + r_w) + SFD - SFW$$

$$(77)\ SFD = \max(0, .5 \cdot (PTAXS - ptaxbm) + .5 \cdot (YTAXS - ytaxbm) + .5 \cdot (DIVS - divsbm))$$

$$(78)\ SFW = \max(0, .5 \cdot (ptaxbm - PTAXS) + .5 \cdot (ytaxbm - YTAXS) + .5 \cdot (divsbm - DIVS))$$

$$(79)\ .8 \cdot xpet \quad > SFUND$$

$$(80)\ .67 \cdot SFUND \quad > SFW$$

Indices

i,j – sector

pet – petroleum sector

tnt – tradeable and non-tradeable sectors

h – households

xf – production using maleable capital

v – production using vintage capital

l – labor category

c,cc – corporate sector

cnp –non-petroleum corporate sectors

Variables

P^e – domestic price of exports

P^x – producer prices

P^d – domestic commodity market prices

P^v – price of value-added

P^{va} – price of value-added aggregate

P^{nm} – domestic price of imported intermediates

P^{km} – domestic price of imported capital goods

P^{kd} – price of aggregate domestically produced investment goods

P^{kt} – price of aggregate investment good

P^{sm} – domestic price of imported inventory goods

P^{cm} – domestic price of imported consumer goods

P^{cd} – price of aggregate domestically produced consumer goods

P^{ct} – price of aggregate consumer good

D – commodity market goods

E – comodity exports

X – domestic production

X^{xf} – production with maleable capital

X^v – production with vintage capital

M- commodity imports

RER – real exchange rate

FSAV – foreign savings

RGDP – real GDP

GDPVA – GDP value-added

PINDEX – domestic price index

CPI – consumer price index

L- labor

W – wage rates

K – capital

k^{xf} – maleable capital

K^{v} – vintage capital

r – return to capital

YF – factor income

WFD – factor returns proportionality variable

UNEM – unemployment

VA – factor aggregate

NTD – domestically produced intermediate aggregate

NTM – imported intermediate aggregate

NTT – aggregate intermediate

INT – total domestically produced intermediate demand

INTM – total imported intermediate demand

NT – sectoral intermediate demand

YCOR – corporate income

YSAV – corporate savings

YH – household income

HSAV – household savings

CTT – consumption aggregate

CD – domestically consumption aggregate

CM – imported consumption goods

CN – sectoral consumption demand

GOVY – government income

GOVSAV – government savings

GOVCON – government consumption

GD – sectoral government consumption demand

OILTAXS – total petroleum taxes

PTAXS – petroleum royalties

YTAXS – petroleum income taxes

DIVS – petroleum sector dividends

FXDINV – fixed investment

DST – changes in inventory

IDT – aggregate investment

IDD – domestic investment aggregate

IDM – imported investment goods

SFUND – stabilization fund

SFD – stabilization fund deposits

SFW – stabilization fund withdrawals

Parameters

pw – world prices

t – tariff rates

tx – sectoral tax rates

sub – sectoral subsidy rates

α– value-added function exponents

a – production function coefficient

tfp – total factor productivity

wfd – factor return proportionality coefficient

r – return to capital

c – factor use coefficients for petroleum and vintage capital production

io, iof – intermediate input requirements

ρ - substitution parameters

δ, ϕ, π, γ, λ - share parameters

$\eta\kappa$ - unemployment function parameters

Intertemporal capital accumulation

$$K_{t,i}^{v} = \theta \cdot K_{t-1,i}^{xf} \cdot (1-\tau)$$

$$K_{t,i}^{xf} = (1-\theta) \cdot K_{t-1,i}^{xf} \cdot (1-\tau) + INV_i$$

K^v – vintage capital

K^{xf} – maleable capital

θ - conversion parameter, maleable capital to vintage capital

τ - depreciation rate

INV – sectoral investment